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ASSESSMENT OF HEAVY-DUTY GASOLINE AND DIESEL VEHICLES IN CALIFORNIA: POPULATION AND USE PATTERNS

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ABSTRACT

As emissions from light-duty vehicles come under more stringent control, heavy-duty vehicles (HDVs) will account for an ever larger share of total mobile source emissions. Accordingly, the Air Resources Board (ARB) wants improved estimates of air pollutant emissions, especially emissions of oxides of nitrogen and particulates, from HDVs.
To achieve that goal, ARB needs an improved methodology for estimating vehicle miles traveled (VMT) by HDVs in each of the 58 counties and 14 air basins in California. Therefore, in this study, Pacific Environmental Services, Inc. (PES) has developed a new estimation method, based on CALTRANS VMT data and other supplementary data, and has estimated truck VMT for various subregions of the state and for HDV subcategories.

The new methodology utilizes VMT data generated by two CALTRANS annual studies: Truck Program and Highway Performance Monitoring System (HPMS). To fill the gaps between the types of information extractable from the CALTRANS data and those needed by ARB, several types of auxiliary data have been acquired through literature search and two special surveys: a special truck traffic survey on 21 different routes selected from city and county roads; and a telephone questionnaire survey on vehicle usage of 622 randomly selected HDVs. Also, out-of-state truck activities in California have been estimated by analyzing data from the 1976 Interstate Commerce Commission Survey and the 1971 Institute of Transportation and Traffic Engineering Survey.

The CALTRANS data bases and the auxiliary data were merged in a computer program named "HDV", especially developed by PES, to compute truck VMT for many geographical subregions and for HDV subcategories. The results are presented in a tabular form in the report.

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1.0 INTRODUCTION AND SUMMARY

1.1 OVERVIEW

As emissions from light-duty vehicles (LDVs) come under more stringent control, heavy-duty vehicles (HDVs) will account for an ever larger share of total mobile source emissions. Accordingly, the Air Resources Board (ARB) wants improved estimates of air pollutant emissions, especially emissions of oxides of nitrogen (NOx) and particulates (TSP and PM10), from HDVs, as well as an improved methodology of estimating vehicle miles traveled (VMT) by HDVs in each of the 58 counties and each of the 14 air basins in California.

Currently, VMT is estimated by taking the sum of products of the number of registered HDVs in each vehicle weight category and the typical annual mileage accumulation rate of HDVs in that category, over all categories. In a similar manner, a composite emission factor for each HDV category and for the entire HDV population is calculated from a set of laboratory-determined emission factors, with the aid of a computer routine such as EMFAC (ARB 1980).

The currently used method has two major drawbacks:

1. The range of operation of an HDV is not limited to the county where it is registered but often extends over several counties and sometimes over several states. Thus, the actual VMT in a given county may differ considerably from the estimated VMT based on vehicle registration data and a typical annual mileage accumulation rate.

2. Unlike passenger cars, the actual weight of an HDV may vary greatly, depending on the degree of loading and how many trailers it pulls. Thus, DMV vehicle registration data reporting "unladen weight" of vehicles are not readily usable in classifying California-based HDVs into the gross vehicle weight (GVW) - based weight classes: light ($8{,}500 < GVW \leq 14{,}000$ pounds), medium ($14{,}000 < GVW \leq 33{,}000$ lbs), and heavy ($GVW > 33{,}000$).

This review of the existing system for estimating HDV emissions has led us to believe that a further significant improvement can be made if estimates of HDV activity (i.e., VMT) are based on detailed truck-activity information available from the Department of Transportation (CALTRANS) rather than on the Department of Motor Vehicles (DMV) registration records, which are presently used as a basis of VMT estimates. In this study, Pacific Environmental Services, Inc. (PES) has developed an alternative estimation method, based on CALTRANS VMT data and other supplementary data, and has applied it to estimate truck* VMT by HDV category in counties and air basins of California.

The methodology utilizes VMT and traffic data generated by the CALTRANS annual and biennial studies: Truck Programs, Weigh Station Survey, and Highway Performance Monitoring System (HPMS). Although these three programs provide a wealth of useful information on truck activities on state highways and city and county roads, the data from the three programs alone are not sufficient for the purposes of the present study.

To fill the gaps between the types of information extractable from the CALTRANS data and those needed by ARB, PES has acquired several types of auxiliary data through literature search and two special surveys:

- PES conducted a special truck traffic survey on 21 different routes selected from city and county roads and estimated a truck mix in traffic on each of several different road types.
- PES conducted a telephone questionnaire survey on HDV usage by interviewing 233 fleet operators and collected vehicle usage information on 622 HDVs.
- Through a national transportation expert at the Charles River Associates in Boston, Mass., PES estimated out-of-state truck activities in California, based on the 1976 Interstate Commerce Commission (ICC) Survey and the 1971 Institute of Transportation and Traffic Engineering (ITTE) Survey.

The three CALTRANS data bases and the auxiliary data collected by PES were merged in a computer program named "HDV" to compute truck VMT for many geographical subregions and for HDV subcategories.

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*CALTRANS uses the word, "truck", to mean all types of heavy-duty vehicles including heavy-duty trucks, large pick-ups (those with double tires on each side of the rear axle), buses, tractors and various combination trucks (e.g., tractor-trailer and truck-trailer). Following this customary use of "truck", this report uses "truck" to mean HDV (except where "truck" is used in contrast to other types of vehicles like buses, tractors or trailers.)

1.2 SUMMARY OF FINDINGS

ARB defines HDV and its three weight classes somewhat differently from the standard weight classes used by FHwA and many other organizations. Table 1-1 lists all weight classes as defined by FHwA and by ARB while Table 1-2 lists all acronyms used in this report. (Readers are advised to refer to these two tables for clarifying the definitions of various vehicle classes and acronyms mentioned in this report.)

The following paragraphs summarize the findings of the existing data, the two PES-conducted surveys, and the conclusions reached in the subsequent analyses. For convenient reference, the summary is organized according to the order of the chapters.

1.2.1 VMT ESTIMATION METHODOLOGY (SECTION 2.0)

- Among the four general road types (interstate, other arterial, collector and local), interstate highways account for 36% of the state-total VMT for trucks while other arterial streets account for 54%. Collector streets carry 10% and local roads are assumed to carry no significant truck traffic.

- Light HDVs are estimated to constitute 45% of the 2-axle trucks in traffic while medium HDVs are estimated to constitute 55% of the 2-axle trucks, 70% of the 3-axle trucks and 33% of the 4-axle trucks. Heavy HDVs are estimated to constitute 100% of the 5+ axle trucks, 67% of the 4-axle trucks and 30% of the 3-axle trucks in traffic.

- Two-axle trucks are most prevalent on urban, nonstate roads while 5+axle trucks are most prevalent on rural state highways. Four-axle trucks are least prevalent on every type of road.

- Out-of-state trucks are estimated to contribute 27% of statewide VMT by heavy HDVs, 6% of VMT by medium HDVs, and 3% of VMT by light HDVs.

- Nearly all light HDVs are powered by gasoline while nearly all heavy HDVs are powered by diesel oil. Medium HDVs are powered by both gasoline and diesel oil. HDVs powered by other types of fuel account for about 1% of the total HDVs.

1.2.2 VMT FOR COUNTIES (SECTION 3.0)

- On a statewide basis, 36 million truck miles are driven daily on state highways (69%) and on city and county roads (31%). Of

Table 1-1. FHwA VEHICLE WEIGHT CLASSES AND ARB HEAVY DUTY VEHICLE CLASSES

	FHwA Weight Class	Gross Vehicle Weight	ARB HDV Class	Gross Vehicle Weight
Single Unit Trucks	Class I	1- 6,000 lbs		
	Class II	6,001-10,000 lbs		
	Class III	10,001-14,000 lbs	Light HDV	8,501-14,000 lbs
	Class IV	14,001-16,000 lbs		
	Class V	16,001-19,500 lbs		
	Class VI	19,501-26,000 lbs	Medium HDV	14,001-33,000 lbs
	Class VII	26,001-33,000 lbs		
	Class VIII	Over 33,000 lbs	Heavy HDV	Over 33,000 lbs
Combination Trucks	Single Trailers			
	Double Trailers			

Note: HDVs include combination trucks as well as single-unit trucks in this report.

Table 1-2. LIST OF ACRONYMS

A.B.	Air Basin
ARB	California Air Resources Board
CALTRANS	California Department of Transportation
CEC	California Energy Commission
COL	Collector Roads
DMV	California Department of Motor Vehicles
DVMT	Annual Average Daily Vehicle Miles of Travel
FHwA	Federal Highway Administration
GVW	Gross Vehicle Weight
HDV	Heavy Duty Vehicles
HPMS	Highway Performance Monitoring System
ICC	Interstate Commerce Commission
INT, IS, I	Interstate Highways
IRP	International Registration Plan
ITTE	Institute of Transportation and Traffic Engineering at UC Berkeley
JFA	Jack Faucett Associates, Inc.
LDV	Light Duty Vehicle
LPG	Liquefied Petroleum Gas
MA	Minor Arterial Roads
MJC	Major Collector Roads
MNC	Minor Collector Roads
OFE	Other Freeways and Expressways
OPA, PA	Other Principal Arterial Roads
PES	Pacific Environmental Services, Inc.
PM10	Particulate Matter with particles whose aerodynamic diameter is less than 10 m
TASAS	Traffic Accident Surveillance and Analysis System
TIUS	Truck Inventory and Use Survey
TSP	Total Suspended Particulate Matter
VMT	Vehicle Miles of Travel

them, 15 million (41%) occur in rural areas and 21 million (59%) in the urban areas.

- As to statewide truck mix, 2-axles contribute the greatest share (46%) of statewide truck VMT, followed by 5+axles (38%), 3-axles (12%) and 4-axles (4%). In rural areas, 5+axles dominate over 2-axles by a margin of 3 to 2 while in urban areas, 2-axles are, by far, the most prevalent.

- On a statewide basis, heavy HDVs account for the largest percentage (44%) of the state total truck VMT, followed by medium HDVs (35%) and light HDVs (21%).

- Of 58 counties in California, VMT by heavy HDVs is preponderant in 46 counties while, in eight counties including Los Angeles, San Diego and San Francisco, VMT by medium HDVs is preponderant. Only in Mariposa County is the proportion of VMT by light HDVs the greatest.

- On a statewide basis, out-of-state trucks account for 18% of all truck VMT on rural roads, 13% on urban roads and 15% for all roads. These out-of-state trucks contribute to the statewide truck VMT by 5.3 million VMT per day, of which 81% are traveled by heavy HDVs.

- Among the 58 counties, Kern County has the highest proportion of VMT contributed by heavy HDVs among out-of-state trucks (93%) and among California-based trucks (64%). In contrast, San Francisco County has the lowest proportion of VMT by heavy HDVs for out-of-state trucks (63%) and for California-based trucks (19%).

- On a statewide basis, diesel-powered trucks yield more VMT than gasoline-powered trucks (56% vs. 42%). The VMT ratio of diesel- to gasoline-powered trucks is about 2 to 1 on rural roads and 1 to 1 on urban roads. Trucks powered by other types of fuel account for only 1% of truck VMT on both rural and urban roads.

1.2.3 VMT ESTIMATE FOR AIR BASINS (SECTION 4.0)

- The South Coast air Basin (A.B.) accounts for about a third of state total truck VMT on all roads, and slightly over a half on urban roads.

- As for VMT by 2-axles, the South Coast A.B. has the largest VMT (7.0 million), followed by the San Francisco Bay Area A.B. (2.6 million) and the San Joaquin Valley A.B. (1.6 million). However, the South Coast A.B. is narrowly surpassed by the San Joaquin Valley A.B. on VMT by 5+axles.

- On a statewide basis, heavy HDVs accumulate the most (16 million), followed by medium HDVs (13 million) and light HDVs (7 million). Among the 14 air basins, the South Coast A.B. has the largest VMT in all three weight classes. As for rural VMT, however, the San Joaquin Valley A.B. dominates in all three weight classes, surpassing the South Coast and all other air basins.

- On a statewide basis, out-of-state trucks travel 5.3 million miles per day or about 15% of state total truck VMT. These out-of-state trucks travel equally on rural and urban roads, each with 2.6 million vehicle miles per day. As to out-of-state truck content in the traffic, rural roads carry a higher proportion (18%) than do urban roads (13%).

- Among the 14 air basins, the South Coast A.B. is ranked first both in VMT by out-of-state trucks and in VMT by California-based trucks. The second place in VMT by California-based trucks falls to the San Francisco Bay Area A.B while that in VMT by out-of-state trucks falls to the San Joaquin Valley A.B.

1.2.4 TRUCK POPULATION AND USAGE PATTERNS (SECTION 5.0)

- The total vehicle population in 1983 is 17.2 million; the truck population including pickups and vans is 3.9 million; and the large truck population, which seems to reasonably approximate the HDV population, is 571,000. In addition, 172,000 out-of-state vehicles operate at least partially in California.

- The numbers of light, medium and heavy HDVs in California for 1983 are estimated to be 263,000, 171,000 and 137,000, respectively. In addition, there are 172,000 out-of-state trucks, which are considered to be mostly heavy HDVs.

- The annual mileage accumulation rate is 13,000 for light HDVs and 23,000 for medium HDVs but that for heavy HDVs is 76,000. A similar difference in the annual mileage accumulation rates is seen between gasoline-powered HDVs (22,000) and diesel-powered HDVs (70,600).

- The average present odometer reading is 51,000 miles for light HDVs, 111,000 miles for medium HDVs and 409,000 miles for heavy HDVs.

- Average unladen weights of light, medium and heavy HDVs are, respectively, 8,700, 10,000 and 23,700 pounds while average laden weights of the three weight classes are 11,300, 21,400 and 68,200 pounds, respectively.

- The percentage of vehicle use by season is the highest during the summer (31.8%) and the lowest during the winter (21.2%), with 25% being the annual average quarterly use.

1.2.5 UNCERTAINTIES, PROJECTIONS AND FURTHER IMPROVEMENTS (SECTION 6.0)

- CALTRANS' three traffic monitoring systems (TASAS, Truck Program and HPMS) provide consistent estimates of state total VMT, differing by only a few percentage points.

- Two axles and six tires constitutes a useful criterion for visually distinguishing trucks from other vehicles but not an accurate criterion for differentiating HDVs from other vehicles. Therefore, the approximation of HDVs by CALTRANS-defined "trucks" could be a major source of errors in estimating truck VMT.

- As to the accuracy of CALTRANS VMT data, 90% confidence limits of all-vehicle VMT estimated by the HPMS Program and truck VMT by the Truck Program are considered to be within $\pm$ 5% at a state level.

- Applications of the apportioning parameters, such as percentage of out-of-state trucks in heavy HDVs, to the spatially resolved CALTRANS VMT data may have introduced significant errors in local VMT estimates. Therefore, VMT estimates given for small geographical areas and for small subcategories of HDVs should be used with caution.

- The truck population is predicted to grow from 571,000 HDVs in 1983 to 601,000 HDVs in 1990 and 644,000 HDVs in 2000.

- The state total truck VMT is predicted to grow from 36 million miles of travel per day to 46 million in 1990 and 60 million in 2000.

- ARB should study the GVW distributions for 2-axle, 6-tire vehicles in pickup, van and other light vehicle types to determine how well CALTRANS-defined "trucks" approximate HDVs.

- ARB should analyze data from the recently completed CALTRANS survey of 6,000 trucks, whose operators were interviewed at weigh stations last August, in order to refine the estimates of out-of-state truck activities on California roads.

- ARB should use a set of vehicle-type-specific, road-type-specific diurnal profiles of vehicle traffic to obtain accurate hourly VMT estimates for HDVs.

2.0 VMT ESTIMATION METHODOLOGY

The California Air Resources Board (ARB) currently estimates annual truck VMT in the State and in each of State's 58 counties as a product of the number of HDV registrations and an average annual mileage accumulation rate reported for the HDV's. Such an estimation method is simple in the concept and straight forward in the computation. However, the method seems to have some problems and drawbacks.

One problem of the present method is that even a slight misestimate in the mileage accumulation rate may result in an across-the-board bias in truck VMT estimates for counties and air basins. Another problem is that if a county receives a net influx or outflux of VMT by out-of-county trucks, the present method is doomed to misestimate its VMT and thus is unable to yield a correct spatial distribution of truck VMT over many different geographical areas such as counties and air basins.

As a practical tool for developing a statewide inventory of truck VMT, the present ARB method has the following drawbacks:

- The Department of Motor Vehicles (DMV) uses "Unladen Weight" of trucks for its weight fee system while ARB's definition of HDV's and their three weight classes is based on "Gross Vehicle Weight" (GVW) of trucks. Therefore, DMV registration records are not easily reducible to ARB's three weight classes: light-HDV ($8{,}500 < GVW \leq 14{,}000$ lbs), medium-HDV ($14{,}000 < GVW \leq 33{,}000$ lbs), and heavy-HDV ($GVW > 33{,}000$ lbs).

- The annual mileage accumulation rates used for the estimation are not based on California-specific data but are taken from some national estimates, which were made many years ago. In addition, the accumulation rates are given only for a few HDV categories despite the fact that they vary greatly from category to category (e.g. recreational vehicle vs. 5-axle trucks).

- The present method fails to work for counties and air basins where most of their trucks VMT are accrued by trucks registered elsewhere. There appear to exist several such counties and air basins which have the small resident population but contain one or more major truck traffic routes.

The first and second drawbacks can be remedied by using certain corrective measures, but the third and the two problems stated earlier seem to result from a shortcoming inherent in the present estimation method.

After reviewing various VMT estimation methods and available or accessible data sources, PES has found that a further significant improvement can be made if estimates of HDV activity (i.e., VMT) are based on detailed truck activity information available from the Department of Transportation (CALTRANS) rather than on DMV's registration records.

However, the CALTRANS data are neither adequate nor readily usable in their original form. PES reviewed CALTRANS traffic data and identified three useful data bases: annual truck traffic counts at some 2,500 highway segments; biennial truck weigh-station surveys at 16 locations; and annual updates of the FHwA highway performance monitoring system (HPMS).

In addition to these three data bases, several types of auxiliary data were collected to fill the gaps between the types of information extractable from the existing data bases and the types of information needed by ARB. The auxiliary data collected include: a special truck traffic survey, on 20 city and county roads, which was conducted by PES; a telephone questionnaire survey on vehicle usage of 622 randomly selected trucks (also done by PES); and an estimation of out-of-state trucks on California roads, which was made by a national transportation consultant for PES.

More detailed discussions on the revised VMT estimation method are presented in Section 2.1, while detailed descriptions of the three CALTRANS data bases are given in Section 2.2. Section 2.3 describes the special truck traffic survey conducted by PES. Section 2.4 discusses an estimate of out-of-state truck activity in California, while Section 2.5 does that of motive power, namely, percentages of gasoline-and diesel-powered trucks.

2.1 REVISED METHOD OF ESTIMATING TRUCK VMT

The major purpose of the truck VMT assessment procedure is to facilitate estimation of total travel by HDVs of any selected class within any given county. The present ARB method is based on two assumptions: an explicit assumption that the average annual mileage is one figure for all gasoline-powered HDVs and another for all diesel HDVs; and an implicit assumption that all HDV miles driven outside any home county (i.e., a county where the vehicle is registered) are balanced by HDV miles driven within the county by vehicles from outside.

A revised method will obviate these questionable assumptions. The first (explicit) assumption can be improved significantly by replacing it with the recent CALTRANS estimates of miles per vehicle (Sydec 1984) or with the estimates derived from the truck usage questionnaire survey, which is described in Section 5.2. However, any improvement to be brought by the use of the newer, more accurate estimates does not obviate the second (implicit) assumption, which seems to pose a more fundamental limitation on the applicability of the present ARB method of estimating truck VMT for sub-regional areas such as counties or air basins.

To obviate the second assumption and the associated limitation, the revised method is based on actual truck activity (i.e., VMT) data instead of indirect estimation through vehicle registration records and annual average miles per vehicle. PES review has identified three major data bases on truck activity, which CALTRANS regulary updates, based on annual surveys on highway traffic and biennial surveys on truck weight. The three data bases are: truck VMT data derived from the annual truck traffic survey conducted on more than 2,500 highway segments; general traffic data computed through the HPMS system, based on the annual traffic survey on about 1,250 highway segments and 1,400 city and county road segments; and truck weight data obtained from the biennial survey at 16 weigh stations.

Although these three data bases provide invaluable information on truck activity in California, they are neither adequate nor readily usable for the purpose of the present study. PES' analysis of information requirements for VMT estimation indicates that certain supplementary information, not available from known sources, will also be important to the implementation of the revised VMT assessment procedure. A logic diagram of the VMT assessment procedure is shown in Figure 2-1.

As Figure 2-1 indicates, truck VMT on state highways (actually, all federal and state highways and some surface streets managed by CALTRANS) will be estimated from two CALTRANS programs: the truck program and the HPMS. Unfortunately, truck VMT on city and county roads cannot be estimated from the CALTRANS data bases alone. After reviewing the problem,

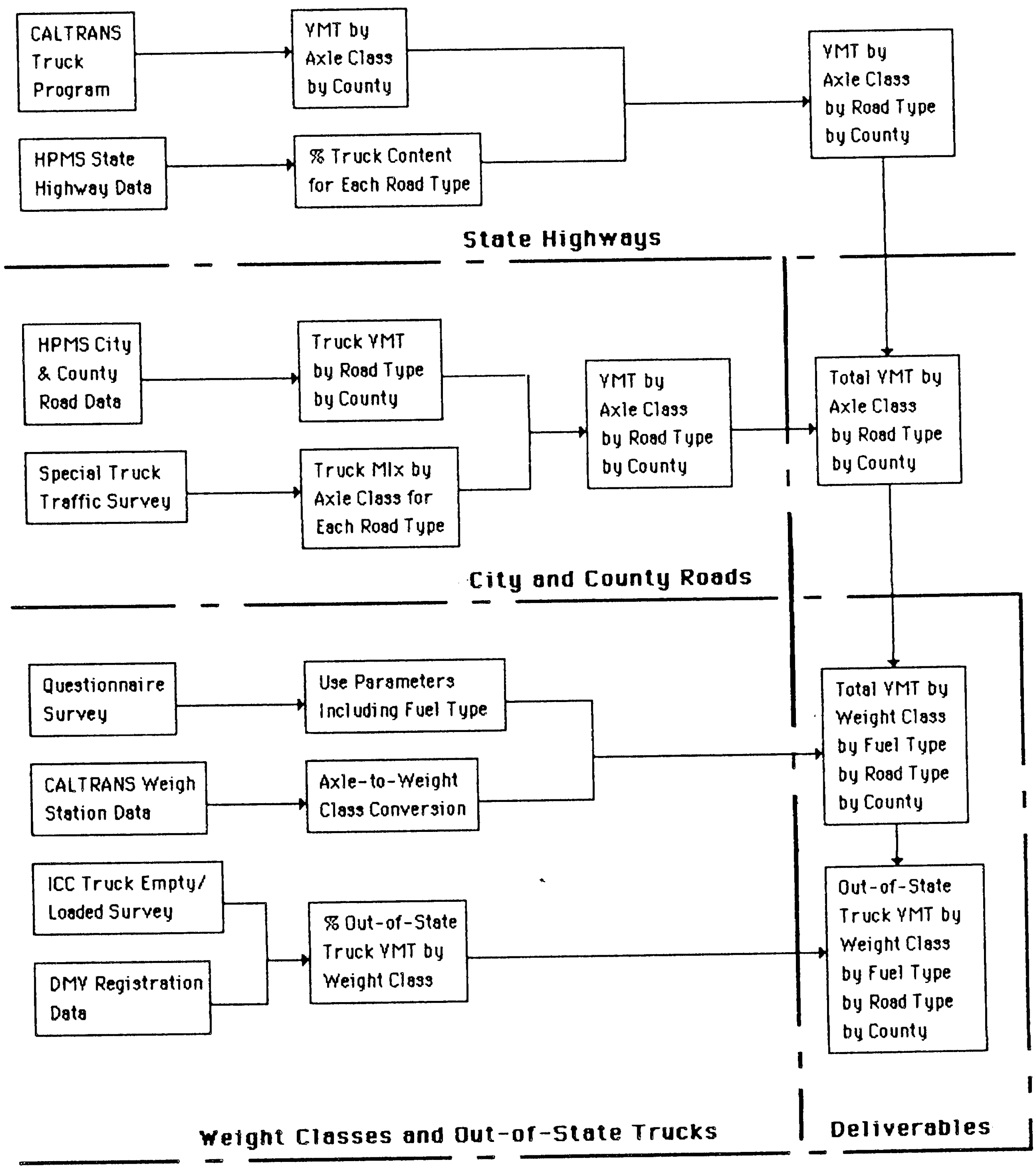


Figure 2-1. Logic Diagram for Truck VMT Assessment

PES concluded that a special truck traffic survey was necessary to obtain the truck traffic mix on various types of city and county roads. Subsequently, PES designed and implemented such a survey. The details of the survey are presented in Appendices A through C, while pertinent results of the survey are summarized and discussed in Section 2.3.

The purposes of the present study are not only to estimate total truck VMT in each county and in the state but also to estimate the distribution of such VMT by HDV weight class, motive power (i.e., gasoline or diesel-powered), and California vs Non-California vehicles. To obtain such information, several supplemental studies were made. A questionnaire survey on truck usage was designed and implemented (see Appendices D and E); results of the questionnaire are summarized and discussed in Section 5.2. The 1982 CALTRANS weigh station data were analyzed to derive a set of relationships between truck axle classes (an observational classifier based on the number of axles per vehicle) and HDV weight classes, (a regulatory classifier based on gross vehicle weight). Results of the 1976 "Empty-Loaded Survey" conducted by the Interstate Commerce Commission (ICC 1977) were analyzed, together with the 1984 DMV registration records, to estimate the percentage of statewide truck VMT accrued by out-of-state vehicles in each of the three weight classes.

Results of the supplemental studies described above were then used to derive detailed distributions of county and state total VMT by weight class, fuel type, out-of-state vehicle, and road type. These calculations were done on an IBM-compatible microcomputer through computer programs developed by PES, called "CTHDV" (for estimating countywide truck VMT) and "ABHDV" (for estimating basinwide truck VMT).

2.2 CALTRANS TRUCK ACTIVITY DATA

PES concluded that three CALTRANS data bases, which are annually or biennially updated, would be very useful for estimating truck VMT on state highways and city and county roads. These three data bases are: Truck Program, HPMS, and Weigh Station Data. The following subsections discuss these data bases as to their content, methods of collecting and updating the data, what portions are exploited in the present study, and how they are used.

2.2.1 TRUCK PROGRAM DATA

CALTRANS' Division of Traffic Engineering conducts a statewide traffic survey during the summer months (usually in July and August) every year. The survey counts trucks and all vehicles passing by at each of some 500 observation points throughout the state highway system during a 6-hour period (usually 9 a.m. to 3 p.m.). Trucks are counted separately for 2-axle, 3-axle, 4-axle, and 5-and-more-axle trucks. A "truck" is defined as a single-unit vehicle with six or more tires, or such a vehicle together with trailers. This definition effectively distinguishes "trucks" from light or medium duty vehicles in most cases. However, there are a few exceptions: a small pick-up (less than 1 ton loading capacity) with six tires is not considered to be a "truck", and off-road vehicles such as construction machines and farm vehicles are also excluded. The definition excludes all light-duty combinations such as a passenger car with trailer, a four-tire pick-up with trailer, and a four-tire van with trailer.

The number of trucks so counted during the six-hour period is extrapolated to the 24-hour day period by a conversion factor, which has been derived from a past survey of 24-hour traffic. The numbers so extropolated are directly used to update the daily truck traffic volumes at the 500 surveyed locations and indirectly used to estimate the corresponding traffic volumes at some 2,000 non-surveyed locations for that year. These 500 survey locations are rotated from year to year so that the estimated traffic volumes at all 2,500 locations will be verified by actual traffic counts at least once every five years.

Results of the annual truck traffic survey described above are published every year by CALTRANS in a report entitled, "Annual Average Daily Truck Traffic (AADTT) on the California State Highway System." These AADTT data are then merged with the highway mile data, which have been compiled and periodically updated by CALTRANS to reflect the current lengths of highway segments associated with some 2,500 traffic observation points. This merger of the traffic volume data and the highway mile data are done by a special CALTRANS computer program to estimate annual average daily VMT accrued by trucks in each of the four axle classes on each of some 2,500 highway segments over the entire state.

PES obtained from CALTRANS a highly aggregated summary of the so calculated VMT. The summary provides annual average daily VMT by axle class for each of the 50 counties which belong to single CALTRANS districts. For the remaining 8 counties, each of which belongs to two different districts, the summary provides VMT values separately for each of the two district portions of the county. The county total VMT for each of these eight counties was computed by adding the VMT values of both district portions. Since the truck program's traffic data are for the summer months, which usually exhibit a higher traffic volume than the annual mean, the final VMT values are adjusted by CALTRANS slightly downward to reflect the annual average daily VMT levels. Such an adjustment is made by comparing two state-total VMT values for all vehicles: one arrived at from traffic data of the truck program; and the other arrived at from those of the traffic accident surveillance and analysis system (TASAS), which contains traffic data collected in all four seasons. The estimated truck VMT by axle class and by county is presented in Table 2-1.

2.2.2 HPMS DATA

The highway performance monitoring system (HPMS) is a nationwide program, which is guided by FHwA and managed by the transportation departments of participating states. HPMS is a comprehensive, computerized system, which is designed to quantify both the physical and operational conditions of a transportation system (i.e., a network of highways, streets, and roads). Quantities of particular interest (within the huge volume of information, which the HPMS computer program provides) are the road miles and VMT, which are given for each of 12 functional classes (i.e., FHwA's official classification of highways, streets and roads according to their presumed functions) and each of 58 counties in California. Another useful quantity is the cumulative road miles of each functional class over California, which are calculated separately for eight different ranges of

Table 2-1. TRUCK DVMT BY AXLE CLASS ON STATE HIGHWAY SYSTEM
(1982 values)

County	2-Axles	3-Axles	4-Axles	5+Axles
ALAMEDA	320,579	132,651	49,554	626,278
ALPINE	1,862	433	42	1,396
AMADOR	13,277	5,690	260	13,046
BUTTE	36,313	10,305	3,016	34,416
CALAVERAS	12,880	4,372	276	10,529
COLUSA	26,335	7,607	5,155	103,880
CONTRA COSTA	144,473	56,777	18,317	273,879
DEL NORTE	12,904	6,462	1,160	18,924
EL DORADO	45,130	16,648	2,616	28,685
FRESNO	172,864	48,472	35,083	490,260
GLENN	21,786	7,276	4,829	87,263
HUMBOLDT	48,393	39,981	5,964	78,090
IMPERIAL	76,445	15,213	8,882	163,757
INYO	43,914	8,818	6,290	37,998
KERN	331,679	82,361	65,619	1,157,703
KINGS	30,628	8,634	5,940	118,287
LAKE	24,402	5,564	2,037	8,632
LASSEN	32,025	13,805	5,464	27,940
LOS ANGELES	2,752,750	627,742	272,811	1,758,976
MADERA	58,216	14,161	8,996	178,310
MARIN	58,162	16,269	3,222	45,652
MARIPOSA	5,606	726	94	1,083
MENDOCINO	57,473	29,549	7,826	67,247
MERCED	86,154	29,766	16,689	306,534
MODOC	12,921	5,410	2,199	10,308
MONO	13,818	5,873	6,205	16,357
MONTEREY	116,735	33,572	16,720	155,303
NAPA	25,999	8,050	1,791	18,264
NEVADA	28,607	10,023	2,905	52,128
ORANGE	685,008	152,160	82,294	380,795
PLACER	101,447	29,194	8,076	108,172
PLUMAS	10,439	5,702	2,095	13,788
RIVERSIDE	435,302	93,370	61,352	737,301
SACRAMENTO	205,190	55,614	21,086	250,584
SAN BENITO	29,388	5,495	2,684	32,760
SAN BERNARDIN	434,513	167,562	111,368	795,727
SAN DIEGO	592,326	115,530	50,825	285,073
SAN FRANCISCO	81,163	16,396	5,277	23,129
SAN JOAQUIN	116,963	46,522	21,002	373,978
SAN LUIS OBIS	103,432	26,182	13,630	118,229
SAN MATEO	197,630	58,026	18,257	130,742
SANTA BARBARA	113,935	33,154	15,369	140,324
SANTA CLARA	252,753	97,751	32,244	394,572
SANTA CRUZ	49,516	15,837	2,227	38,748
SHASTA	87,721	40,626	19,147	172,083
SIERRA	8,150	4,445	1,011	8,663
SISKIYOU	56,613	60,699	17,114	197,419
SOLANO	93,362	41,815	15,890	214,293
SONOMA	81,246	32,258	5,449	110,539
STANISLAUS	56,791	22,014	8,090	152,115
SUTTER	25,440	4,303	2,508	31,273
TEHAMA	42,351	16,536	7,250	118,904
TRINITY	10,870	8,007	977	13,916
TULARE	125,786	33,511	16,721	437,968
TUOLUMNE	16,805	5,004	244	13,868
VENTURA	234,391	44,451	15,719	114,094
YOLO	57,736	18,663	8,150	122,866
YUBA	20,726	4,207	1,289	19,467

"truck percentage." Here, "truck percentage" means what percentage of traffic is accounted for by trucks.

From the latter quantity, an average truck percentage in each functional class was computed as:

$$\overline{C} = \sum_i R_i C_i / \sum_i R_i \quad (i=1,2,\ldots.,8) \qquad (2\text{-}1)$$

where C is the average truck percentage, C_i is the midpoint value of the i-th range of truck percentage and R_i is the road miles on which truck percentage is found to be in the i-th range. Table 2-2 shows the 1983 rural and urban system road miles in each of 8 ranges of truck percentages: 0-5%, 6-9%, 10-13%, 14-17%, 18-21%, 22-25%, 26-29%, and over 29%. For the last range, the midpoint was estimated as 31.5%.

CALTRANS classifies road segments into 12 functional classes: 6 rural functional classes and 6 urban functional classes. Table 2-2 does not include the sixth functional class: rural local roads and urban local roads. Although these local roads have more road miles than all the other functional classes combined, CALTRANS provides no specific estimates of the percentage of trucks on such roads; and truck traffic being assumed negligible.

The relative magnitudes of road miles and all-vehicle VMT in each of four road types (interstate highways, other arterial streets, collector streets, and local roads) were determined from the state-total values which appeared in the HPMS report (CALTRANS 1984) and are graphically shown in Figure 2-2. It should be noted that in spite of the overwhelming number of road miles, local roads account for only about 10% of state-local VMT by all vehicles. Interstate highways and other arterial streets, which constitute only about 15% of state-total road miles, account for about 80% of state-total VMT.

Figure 2-3 shows similar distributions of road miles and VMT for "trucks". While other arterial streets and collector streets account for about the same percentage (i.e., 54% and 10%, respectively) of state-total VMT as in the case of all vehicles, interstate highways account for 36% of the state-total VMT for trucks compared to 24% of the state-total VMT for all vehicles. This shift of truck VMT toward interstate highways is

Table 2-2. 1983 RURAL AND URBAN SYSTEM MILES BY PERCENT TRUCKS (24-HR. AVG.) AND CALCULATED MEAN PERCENT TRUCKS FOR EACH FUNCTIONAL CLASS

RURAL ROAD MILES BY PERCENT TRUCKS

FUNCTIONAL CLASS	CODE	0 - 5	6 - 9	10-13	14-17	18-21	22-25	26-29	OVER 29 %	TOTAL MILES	MEAN % TRUCK
Interstate	(01)	4	83	148	352	93	179	72	513	1445	22.1%
Other Principal Arterial	(02)	177	698	1003	482	255	127	92	234	3067	13.9
Minor Arterial	(06)	1955	1674	1061	686	539	239	7	549	6709	11.0
Major Collector	(07)	4491	2840	2408	1183	891	153	0	974	12941	10.1
Minor Collector	(08)	4460	2674	897	1175	273	534	0	228	10242	8.3
TOTAL		11087	7969	5518	3879	2051	1233	171	2497	34404	10.6

URBAN ROAD MILES BY PERCENT TRUCKS

FUNCTIONAL CLASS	CODE	0 - 5	6 - 9	10-13	14-17	18-21	22-25	26-29	OVER 29 %	TOTAL MILES	MEAN % TRUCK
Interstate	(11)	274	323	154	143	20	4	4	15	937	8.7
Other Freeway & Expressway	(12)	329	468	117	64	21	32	6	16	1113	8.3
Other Principal Arterial	(14)	3673	1134	419	49	46	13	3	111	5448	5.2
Minor Arterial	(16)	5048	1344	643	132	15	5	57	281	7527	5.7
Collector	(17)	5280	1122	236	24	77	53	0	14	6805	4.1
TOTAL		14603	4392	1628	412	180	107	70	437	21829	5.3

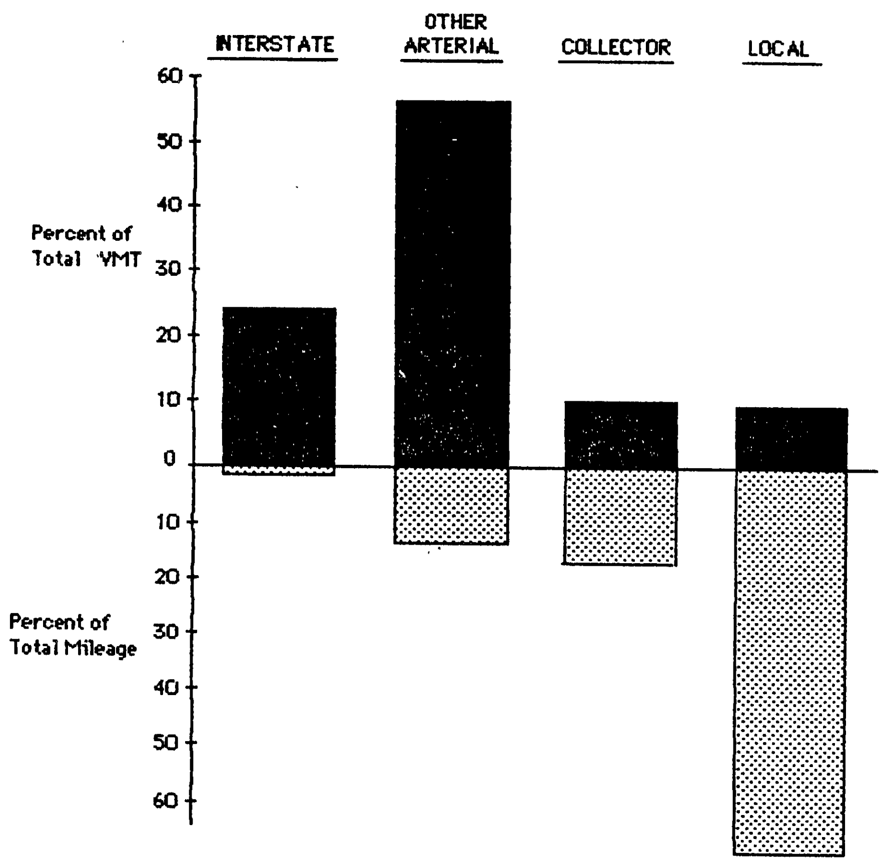


Figure 2-2. Statewide Distribution of All-Vehicle VMT and Road Miles over Four Major Road Types.

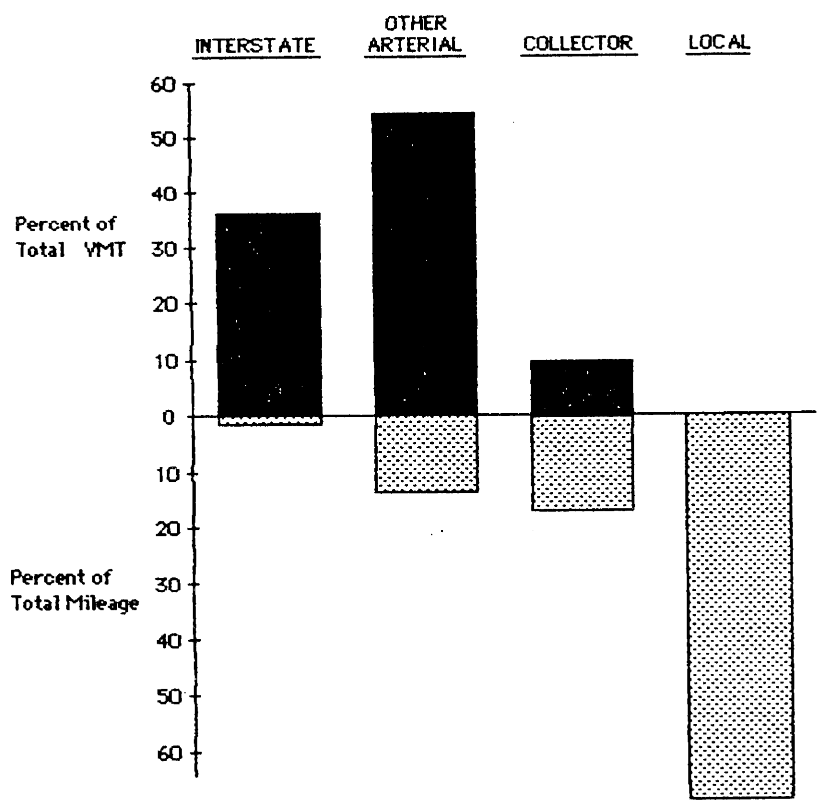


Figure 2-3. Statewide Distribution of Truck VMT and Road Miles over Four Major Road Types.

consistent with the assumption that truck VMT on local roads is negligibly small as compared to truck VMT on the other road types.

As to all-vehicle VMT by county by functional class, CALTRANS computed and tabulated this quantity in great detail for the year of 1982 but, thereafter, calculated only the state-total VMT by functional class. Therefore, PES used the 1982 VMT values by county by functional class as a fundamental data base and applied a VMT growth factor for each functional class to update the estimates for later years, particularly for 1983.

2.2.3 WEIGH STATION DATA

CALTRANS conducts a biennial truck weight survey at 16 weigh stations scattered over the entire state (Figure 2-4). During the survey, all trucks entering the weigh stations are weighed and the load at each axle is determined. The data are compiled for each weigh station and for each vehicle type; about 50 different vehicle types are recognized. Since the CALTRANS truck classification is too detailed for ARB's purpose, PES aggregated the truck weight data into four axle classes: 2-axles, 3-axles, 4-axles and 5-or-more-axles (i.e., 5+ axles).

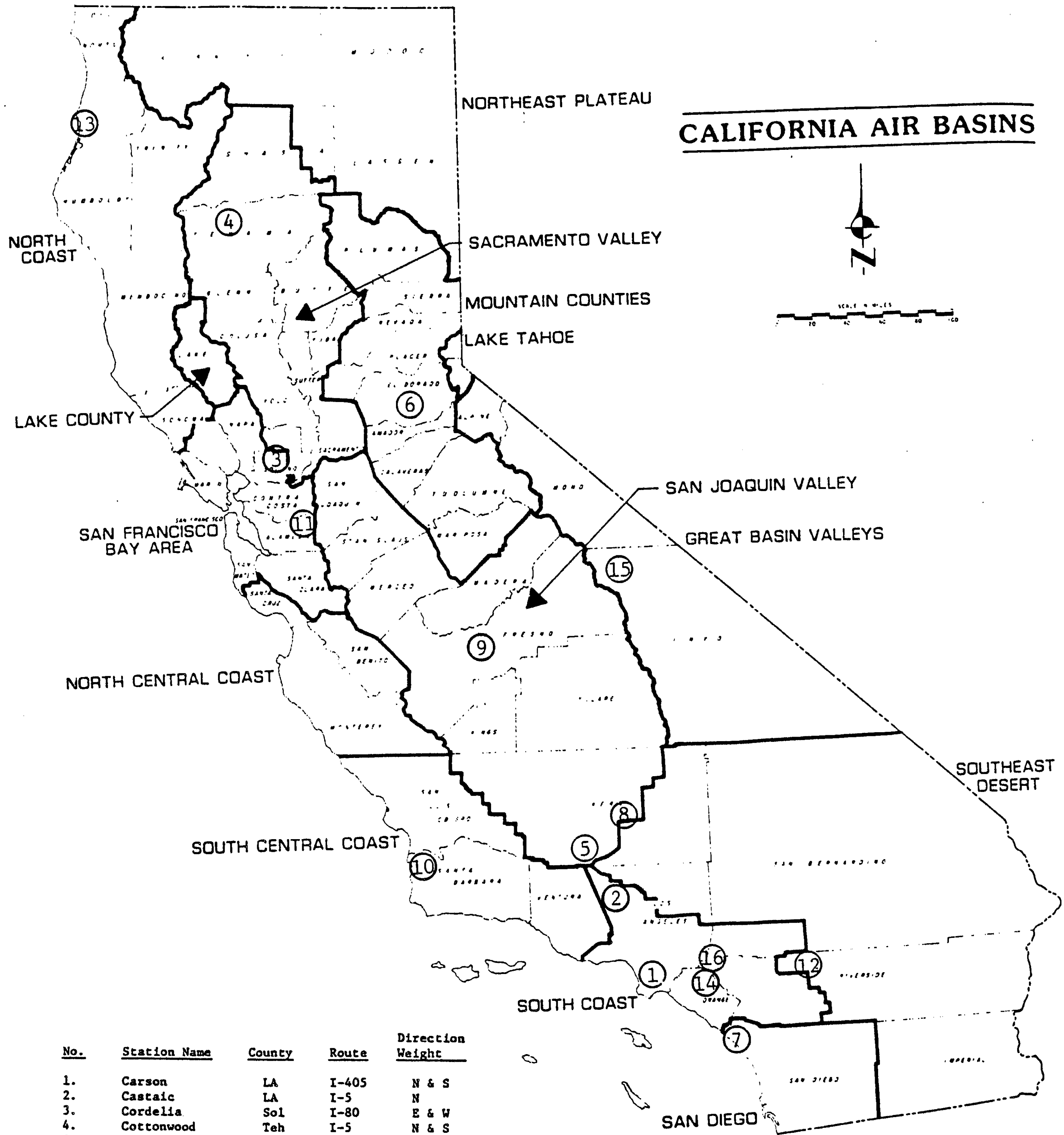
The 1981 weigh station survey data were obtained from CALTRANS and analyzed by PES to determine the relationship between the axle classes which are used by CALTRANS to visually classify trucks and the HDV weight classes which are used by ARB to differentiate trucks in regard to their emission potentials. By applying a packaged statistical program to the data base, three frequency distributions were computed: one for all 6,058 trucks identified in the 1981 survey; one for 4,424 trucks which were partially or fully loaded at the time of the survey; and one for 1,634 trucks which were unloaded at the time of the survey. (Since equipment trucks carry their heavy equipment with them, they are considered as loaded trucks in the above classification. There were only 37 equipment trucks among the 6,058 trucks.)

Table 2-3 provides the number frequencies by axle class for all trucks, loaded trucks and unloaded trucks. The truck mix is dominated by 5+ Axles (68%), followed by 2-Axles (17%), 3-Axles (10%) and 4-Axles (5%).

Table 2-3. VEHICLE WEIGHT DISTRIBUTION BY AXLE CLASS BASED ON 1981 TRUCK WEIGHT SURVEY AT 16 WEIGH STATIONS

Loaded	2-Axle	3-Axle	4-Axle	5+Axle	Total Trucks
All Trucks[a]	1,043	593	301	4,121	6,058
Loaded Trucks[b]	767	368	226	3,063	4,424
Unloaded Trucks	276	225	75	1,058	1,634
Loading Rate (%)*	74	62	75	74	73
Loaded Truck Weight Distribution					
Vehicle Weight	Freq (%)**	Freq (%)	Freq (%)	Freq (%)	Freq (%)
≤8,500 lb	85 (11)	2 (1)	0 (0)	0 (0)	87 (2)
8,500-14,000	258 (34)	4 (1)	1 (0)	0 (0)	263 (6)
14,000-33,000	419 (55)	254 (69)	73 (33)	79 (3)	825 (19)
>33,000	5 (0)	108 (29)	152 (67)	2,984 (97)	3,249 (73)
Unloaded Truck Weight Distribution					
Vehicle Weight	Freq (%)***	Freq (%)	Freq (%)	Freq (%)	Freq (%)
≤8,500 lb	68 (25)	0 (0)	0 (0)	0 (0)	68 (4)
8,500-14,000	141 (51)	5 (2)	3 (4)	1 (0)	150 (9)
14,000-33,000	67 (24)	218 (97)	66 (88)	785 (74)	1,136 (70)
>33,000	0 (0)	2 (1)	6 (8)	272 (26)	280 (17)

*(b/a) x 100%
**Percent of loaded trucks
***Percent of unloaded trucks



No.	Station Name	County	Route	Direction Weight
1.	Carson	LA	I-405	N & S
2.	Castaic	LA	I-5	N
3.	Cordelia	Sol	I-80	E & W
4.	Cottonwood	Teh	I-5	N & S
5.	Wheeler Ridge	Ker	I-5	S
6.	Camino	ED	US-50	W
7.	San Onofre	SD	I-5	N & S
8.	Keene	Ker	SH-58	E
9.	Jensen Avenue	Fre		E & W
10.	Guadalupe	SB	SH-166	E & W
11.	Livermore	Ala	I-580	E & W
12.	Banning	Riv	I-10	E & W
13.	Little River	Hum	US-101	S
14.	Peralta	Ora	SH-91	E & W
15.	Big Pine	Iny	US-395	N
16.	Chino	SBd	SH-83	N & S

Figure 2-4. Locations of 16 Weigh Stations Employed in 1981 Truck Weight Survey

The ratio of loaded trucks to all trucks (i.e., loading rate) is 73% and is fairly consistent among the four axle classes. The table also provides further detail on the number frequencies by axle class for four weight ranges: 8,500, 8,500-14,000, 14,000-33,000, and 33,000 lbs.

Of 4,424 loaded trucks, 73% are heavier than 33,000 pounds and, thus, are classified as "heavy" HDVs whereas, of 1,634 unloaded trucks, only 17% are heavier than 33,000 pounds and the majority (70%) weigh between 14,000 and 33,000 pounds. Since ARB defines "heavy", "medium" and "light" HDV s according to gross vehicle weight, the loaded truck weight distribution in Table 2-3 may be used to determine a weight factor for each axle class. For 2-Axles, 55% weigh between 14,000 and 33,000 pounds (i.e., medium HDVs. and 45% weigh less than 14,000 pounds (i.e., light HDVs). However, some 2-Axles (11%) weigh less than 8,500 pounds and, thus, may not qualify as HDVs. For 3-Axles, 69% weigh between 14,000 and 33,000 pounds (i.e., medium HDVs) and 29% weigh more than 33,000 pounds (i.e., heavy HDVs). For 4-Axles, 33% are medium HDV s and 67% heavy HDVs. For 5+Axles, nearly all (97%) weigh more than 33,000 pounds.

From the above weight distribution, PES has assigned the weight class factors given in Table 2-4. Using these weight class factors, the numbers of light, medium and heavy HDVs will be estimated from the numbers of 2-, 3-, 4- and 5+axle trucks as:

Light HDVs = 0.45 x 2-Axles (2-2)

Medium HDVs = 0.55 x 2-Axles + 0.70 x 3-Axles + 0.33 x 4-Axles (2-3)

Heavy HDVs = 0.30 x 3-Axles + 0.67 x 4-Axles + 1.00 x 5+Axles (2-4)

Table 2-4. FACTORS FOR CONVERTING AXLE CLASS TO WEIGHT CLASS

	2-Axle*	3-Axle	4-Axle	5+Axle
Light HDV	45%	-	-	-
Medium HDV	55%	70%	33%	-
Heavy HDV	-	30%	67%	100%

(As determined by PES from CALTRANS data of 1981.)

*All 2-axle, 6-tired trucks are assumed to be HDVs.

2.3 SPECIAL TRUCK TRAFFIC SURVEY

After reviewing the CALTRANS data on VMT by trucks, it was evident that truck VMT data for non-state roads (i.e., city and county roads) were very incomplete. Only the HPMS data for non-state roads were useful for estimating total truck VMT on city and county roads. However, the data were inadequate for making separate estimates of VMT by HDV subcategories such as axle class, weight class, motive power (i.e., gasoline vs diesel) and base state (i.e., California vs non-California).

To make such separate estimates possible, PES has conducted the special truck traffic survey (described in this section and in Appendices A through C), the truck usage questionnaire survey (described in Section 5.2 and Appendices D and E), and the data analysis for estimating VMT by out-of-state trucks (discussed in Section 2.4). This section describes the scope and the pertinent results of the special truck traffic survey. A more complete description of the survey and its results presented in Appendices A through C.

CALTRANS has a complete set of road maps showing the functional class by using a different symbol for every road segment (e.g., thick solid line for interstate and other freeways, and thick broken line for minor arterials). Based on these functional class maps, PES selected 21 different routes, each consisting one or two functional classes and road length of 17 miles to 42 miles. One of the routes was used only for a pilot survey, which was to acquire field experience in truck identification and classification. (Three other routes were also used for the pilot survey, but they were resurveyed for the special truck traffic survey.) As a result, 20 different routes consisting of one or two of the three dominant functional classes (i.e., principal arterial, minor arterial and major collector) for truck traffic on non-state roads were surveyed to determine the mix of trucks in their traffic.

Table 2-5 describes all the routes surveyed both in the pilot and the main truck traffic surveys. In the survey, many sub-categories were used to differentiate HDV s from non-HDV s and each type of trucks from the other types. The detailed results using such sub-categories can be found

Table 2-5. SPECIAL TRUCK TRAFFIC SURVEY ROUTES

Route Code	Name of the Area	County		Functional Class	Route In Miles	Date Traveled
1	Carson/Wilmington	LA	(U)	PA	20.5	2/8/84(p),4/3/8
2	Garden Grove/Anaheim	OR	(U)	PA	22.0	2/23/84(p),4/5/8
3	San Fernando Valley	LA	(U)	PA	20.6	2/29/84(p),3/29/
4	Pico Rivera	LA	(U)	PA	22.2	3/1/84(p)
5	Northridge	LA	(U)	MA	17.8	3/22/84
6	Garden Grove	OR	(U)	MA	21.0	3/27/84
7	San Diego-Miramar	SD	(U)	PA(62%)/MA(38%)	20.8	4/12/84
8	San Diego-Downtown	SD	(U)	PA(60%)/MA(40%)	19.7	4/19/84
9	Redwood City	SM	(U)	MA	21.9	4/25/84
10	Sunnyvale	SCL	(U)	PA	21.9	4/25/84
11	San Francisco	SF	(U)	PA(82%)/MA(18%)	20.9	4/26/84
12	Oakland	AL	(U)	MA	22.0	4/26/84
13	San Bernardino	SBD	(M)	PA	24.3	5/3/84
14	Riverside	RIV	(M)	PA	22.2	5/8/84
15	Riverside County	RIV	(M)	MJC	30.6	5/20/84
16	Kern County	KE	(M)	MJC	34.2	5/16/84
17	Bakersfield	KE	(M)	PA	22.3	5/17/84
18	Stockton	SJ	(M)	MJC	35.5	5/23/84
19	Sacramento	SA	(M)	PA	22.0	5/24/84
20	Fresno County	FR	(M)	MJC	40.3	5/30/84
21	Fresno	FR	(M)	PA	21.2	5/31/84

Note: U = Urban County PA = Principal Arterial P = Pilot Traffic Survey
M = Mixed County MA = Minor Arterial MJC = Major Collectors

in Appendix C. These detailed truck counts by subcategory were aggregated into four standard axle classes: 2-Axles, 3-Axles, 4-Axles, and 5+Axles. The average truck mix found in the principal arterial routes, the minor arterial routes, and the major collector routes are graphically depicted in Figure 2-5.

Figure 2-5 shows that truck mixes on urban principal arterials and minor arterials are dominated by 2-axle trucks (68% and 74%, respectively). 5+axle trucks, which are dominant (62%) on state highways, account for only 14.5% and 9.0%, respectively, for the two urban non-state road types. 2-axle trucks are less dominant on rural major collectors (52%) and 5+axle trucks account for 32%.

Figure 2-6 shows daily truck VMT (DVMT) density for each of the three road types. The densities are 1,126 DVMT per mile for urban principal arterials, 598 for urban minor arterials and 237 for rural major collectors. These numbers are to be compared with 914, 488 and 170, which were calculated from the CALTRANS HPMS data. Ratios of the PES value to the HPMS value are rather consistent from road type to road type: 1.23 for principal arterials, 1.23 for minor arterials and 1.39 for major collectors. The higher truck VMT densities in PES' survey results were expected because PES intentionally selected its survey routes from segments which were continuous over 10 to 30 miles. Routes consisting of such road type segments tend to be found only in major traffic corridors for each locale.

The special truck traffic survey conducted by PES has generated the truck mix and truck traffic density information for the three main non-state road types. To obtain similar information for state highway types, PES analyzed the 1981 Vehicle Classification Study data, which were compiled by CALTRANS from results of the latest biennial survey, conducted at the same 16 weigh stations as shown in Figure 2-4. This biennial Vehicle Classification Study is conducted over one 24-hour period at each weigh station and is completed in two months (usually July and August) for all 16 weigh stations. Although the original data were given for each of some 50 different vehicle type, the data were aggregated by PES into four axle classes: non-regular buses + 2-axle trucks with 6 tires for 2-axles;

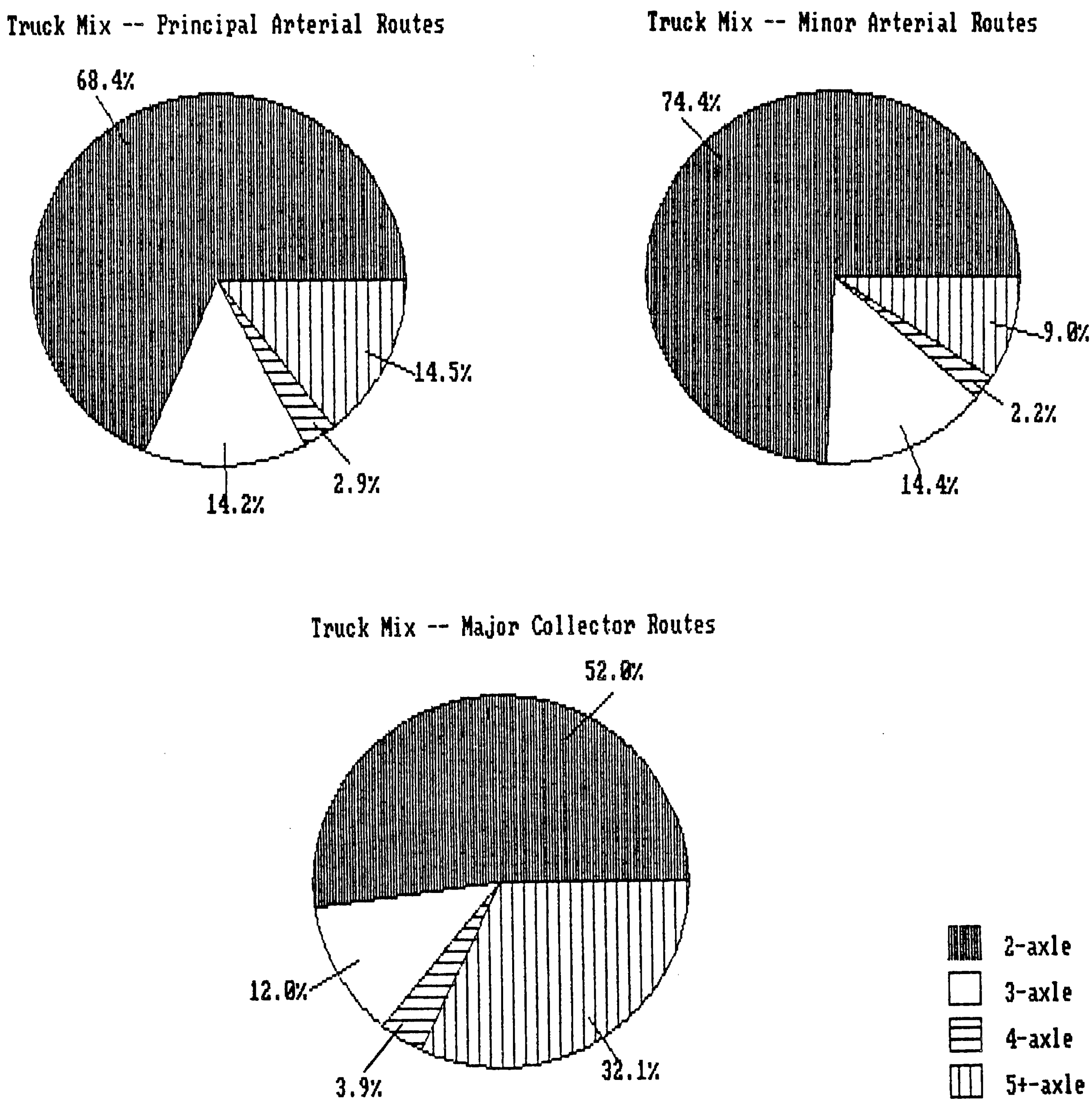


Figure 2-5. Truck Mix on Principal Arterials, Minor Arterials and Major Collectors

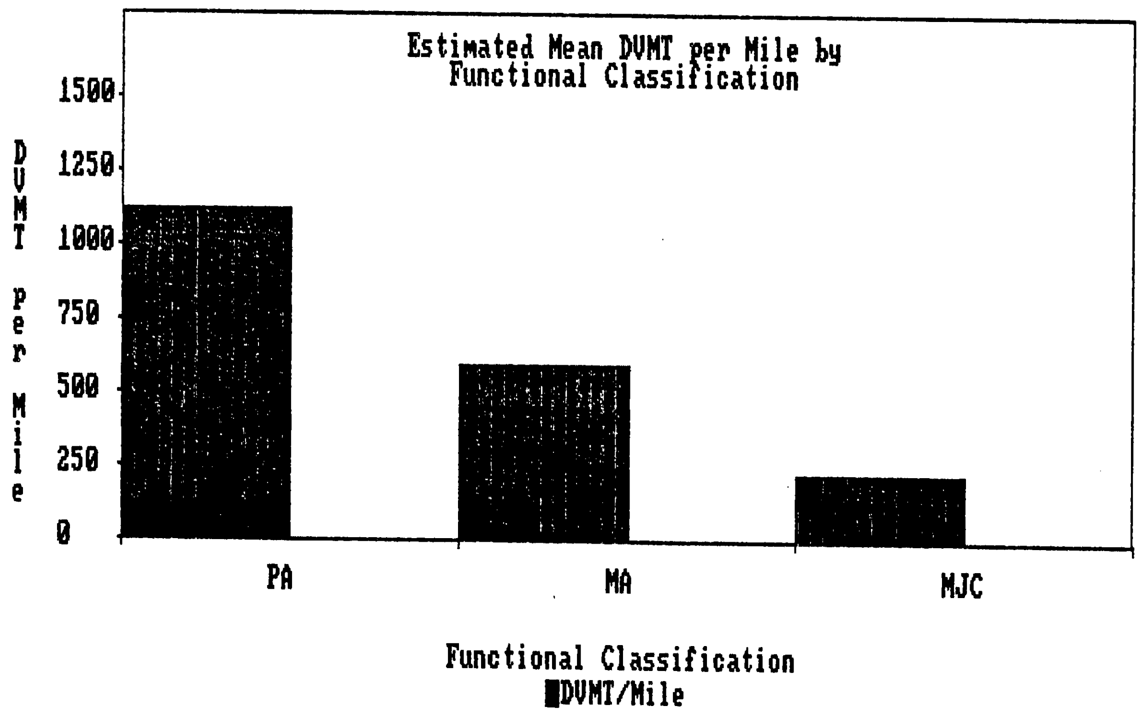


Figure 2-6. Truck VMT Densities on Principal Arterials, Minor Arterials and Major Collectors

commercial buses + 3-axle trucks + 3-axle combinations for 3-axles; 4-axle combinations for 4-axles; and 5-or-more-axle combinations for 5+axles.

Results of the data analysis are summarized in Table 2-6. There is a noticeable difference in truck mix between rural state highways and urban state highways: 5+axle trucks are most abundant on rural highways while 2-axle trucks are equally or more abundant than 5+axle trucks on urban highways. On both rural and urban highways, percentages of 3-axle and 4-axle trucks to total trucks are considerably smaller than those of 2-axle and 5+axle trucks.

Table 2-7 shows the truck mix for each functional road class. The table was prepared by merging the truck mix values obtained from the PES' Special Truck Traffic Survey (presented in Figure 2-5) and those derived from the CALTRANS Classified Vehicle Study (presented in Table 2-6). The truck mixes for rural interstate highways are based on the results of the 1981 Classified Vehicle Study while those for rural major collector roads, urban other principal arterial streets and urban major aterial streets are based on the results of the 1984 Special Truck Traffic Survey. Unfortunately, there are no similar survey data from which truck mixes for rural minor collector roads, urban other freeways and expressways, and urban collector streets can be determined. Therefore truck mixes for these functional classes are estimated from those of the most similar functional classes: truck mixes on rural minor collector and urban collector are estimated by substitution of the truck mix values for rural major collector and urban minor aterial, respectively; and truck mix on urban other freeway and expressway is estimated by linear interpolation of the truck mix values for urban interstate and urban other principal arterial.

A similar interpolation method was used to estimate truck mix on rural minor arterial. Although the CALTRANS Classified Vehicle Study surveyed truck traffic on rural minor arterial, the survey was made only at a remote rural station in Big Pine, Inyo County. Because of the remoteness of the survey site and the unusually small sample size (673 trucks as compared to many thousand trucks for other funtional classes in the Classified Vehicle Study), the truck mix values derived from the survey data were judged to be not representative of statewide truck mix for rural minor arterial.

Table 2-6. TRUCK MIX AT WEIGH STATIONS (after CALTRANS 1981 Vehicle Classification Study)

Code	Functional Class	No. of Stations	Number Frequency (Percent of Total Trucks) 2-Axles	3-Axles	4-Axles	5+Axles	Total Trucks
01	Rural-Interstate	8	9,492 (18%)	4,819 (9%)	2,794 (6%)	34,496 (67%)	51,601
02	Rural-Other Principal Arterial	6	5,039 (24%)	2,317 (11%)	1,110 (5%)	12,382 (60%)	20,848
06	Rural-Minor	1	198 (29%)	119 (18%)	22 (3%)	334 (50%)	673
11	Urban-Interstate	1	4,114 (52%)	1,365 (17%)	607 (8%)	1,823 (23%)	7,909
14	Urban-Other Principal Arterial	2	1,242 (36%)	484 (14%)	181 (6%)	1,515 (44%)	3,422

Table 2-7. TRUCK MIX BY FUNCTIONAL CLASS OF ROADS

Code	Functional Class	Source or Method	Sample Size	Truck Mix as Percent of Total Trucks 2-Axles	3-Axles	4-Axles	5+Axles
01	R-INT	CALTRANS[b]	51,601	18	9	6	67
02	R-OPA	CALTRANS[b]	20,848	24	11	5	60
06	R-MA	Averaging	-	38	11	5	46
07	R-MJC	PES[c]	458	52	12	4	32
08	R-MNC	Substitution[d]	-	52	12	4	32
11	U-INT	CALTRANS[b]	7,909	52	17	8	23
12	U-OFE	Averaging	-	60	15	6	19
14	U-OPA	PES[c]	6,734	68	14	3	15
16	U-MA	PES[c]	1,709	74	15	2	9
17	U-COL	Substitution[d]	-	74	15	2	9

[a]R = Rural, U = Urban, INT = Interstate, OPA = Other Principal Aterial, MA = Minor Arterial, MJC = Major Collector, MNC = Minor Collector, OFE = Other Freeway and Expressway, COL = Collector

bBased on the 1981 Classified Vehicle Study by CALTRANS

[c]Based on the 1984 Special Truck Traffic Survey by PES

[d]See the text for explanation

2.4 OUT-OF-STATE-TRUCK USAGE IN CALIFORNIA

Just as trucks cross county boundaries, they also travel beyond state boundaries. Of particular concern to ARB is the relative magnitude of out-of-state truck activity in California. Since California emission standards for heavy duty vehicles are more stringent than the federal standard which are applied to trucks in the other 49 states, activity in California by out-of-state trucks tends to diminish the effectiveness of the state emission standards for reducing pollutant emissions from trucks.

Therefore, the share of statewide truck VMT accrued by out-of-state trucks was estimated using two existing data bases: the 1976 "Empty/Loaded" Survey conducted by the ICC; and the 1984 Gross Report prepared by the California DMV.

2.4.1 ESTIMATE OF OUT-OF-STATE TRUCKS CONTRIBUTION BASED ON ICC SURVEY DATA

The ICC Survey was conducted nationally during the 12-month period, January 1976 through January 1977 (ICC 1977). With the assistance of state enforcement personnel, over 13,000 trucks with three or more axles and tractors without trailers were stopped on over 200 intercity segments of the Interstate Highway System. The drivers of those vehicles were interviewed by trained ICC staff members who recorded a variety of data regarding the vehicle and haul, including the state in which the vehicle was licensed and the state of domicile of the driver. Over 300 such interviews were conducted on four segments within the boundaries of California, and over 1,200 interviews involving California traffic (regardless of where sampled) were conducted, in total.

Using the data relating to California traffic, the share of statewide truck VMT accrued by out-of-state trucks was estimated as follows:

1. Trucks in California traffic were divided into three groups by their types of traffic: Intrastate -- moves with both origin and destination in California; Interstate -- moves with either origin or destination, but not both, in California; and Bridge -- moves with both origin and destination outside California, but that pass through California en route.

2. The percent of VMT that was accrued by California-licensed trucks was estimated from the California sampling locations for each traffic type. Here, California-licensed trucks were assumed to be those trucks whose license plate or whose driver's domicile was California. (The validation of this assumption is discussed in Appendix F.)

3. Using the percent of California-licensed trucks, C_i, and the percent of trucks found in each of the three types of traffic, T_i ($i = 1, 2, 3$), the percent of VMT attributable to California-licensed trucks, P, was estimated as*:

$$P = \sum_{i=1}^{3} C_i/T_i/100 \qquad (2-5)$$

The two sets of percentage values, C_i and T_i ($i = 1, 2, 3$) which were determined from the ICC Survey data, and the percent of VMT calculated by the above equation, are presented in Table 2-8. Among the trucks in California traffic, PES found that 63 percent were engaged in intrastate traffic while 35 percent were in interstate traffic. Only 2% of the trucks were in bridge traffic. As expected, the percent of California-licensed trucks was the highest (97%) in intrastate traffic, and much smaller in interstate traffic (33%). There were no California-licensed trucks in bridge traffic. A calculation using Eq. (2-5) as shown in Table 2-8, indicated that California-licensed trucks account for 72.6% of total truck VMT in California. In other words, 27.4% of the total truck VMT are attributable to out-of-state trucks. These percentage values are found to be in good agreement with the corresponding national figures, which were also derived from the ICC Survey data.

Since the ICC Survey was done for heavy trucks with three or more axles on interstate highways, the above estimated value of out-of-state truck contribution to truck VMT in California should be viewed as applying to heavy trucks only, rather than for all HDVs (which include large pick-ups, vans and recreational vehicles as well as full-size trucks.) Table 2-9 lists the percentages of out-of-state trucks found at four California locations in the ICC Survey. There seems to exist a pattern that the two interstate routes at Cottonwood and Cajon Pass have the higher proportion

*It is assumed that trucks in a same type of traffic contribute equally to statewide VMT regardless of if they are California-licensed trucks or out-of-state trucks.

Table 2-8. PERCENTAGES OF CALIFORNIA-LICENSED HDVs IN EACH TYPE OF TRAFFIC (Based on Results of the 1976 ICC Survey)

Traffic Type	%Total Traffic	%California-Licensed HDV
Intrastate (Calif. → Calif.)	63.1%	96.9%
Interstate (Non-Calif. → Non-Calif.)	35.0%	32.6% ← (30.3%)
Bridge (Non-Calif. → Calif. → Non-Calif.)	1.9%	0%

%VMT Attributable to California-Licensed HDV's

= (.631 x .969 + .350 x .326 + .019 x 0) x 100%

= 72.6%

%VMT Attributable to Out-of-State HDV's

= (1 - .726) x 100%

= 27.4% ← (27.6%)

( ) = National Average

Table 2-9. SAMPLE PERCENTAGE OF OUT-OF-STATE TRUCKS FOUND AT FOUR LOCATIONS IN CALIFORNIA

(after the 1976 ICC Survey)

Location	Sample Size	%Out-of-State HDV
Cottonwood, I-5	59	54.0
Castaic and Wheeler Ridge, I-5	85	12.0
San Onofre, I-5	80	10.6
Cajon Pass, I-15	81	39.8
	Weighted Average	27.1%

*Surveyed large trucks with 3-axles or more of out-of-state trucks than do the two intrastate routes at Castaic, Wheeler Ridge and San Onofre. Such a pattern is quite consistent with what one expects for truck traffic on the two types of routes.

It is expected to find a similar difference in out-of-state truck proportion between on rural highways and urban highways and streets. As summarized in Table 2-7, the truck composition on urban highways and streets is dominated by light 2-axle trucks, which account for over 50% of total trucks. On the other hand, heavy trucks (5-axles or more) account for over 60% of total trucks on rural highways. Since the great majority of 2-axle trucks are for local use, there is unlikely to be any significant proportion of out-of-state trucks in this category. Thus, it may be reasonable to expect a smaller proportion of out-of-state trucks in urban traffic than in rural highway traffic.

2.4.2 ESTIMATE OF OUT-OF-STATE TRUCK CONTRIBUTION BASED ON DMV DATA

DMV issues two types of licenses for commercial vehicles: apportioned licenses, which are issued for vehicles engaged in interstate commerce; and primary licenses, for vehicles not engaged in interstate commerce. Apportioned-license vehicles primarily consist of intercity buses, single-unit trucks and combination trucks (i.e., tractor-trailers and truck-trailers). The DMV statistical summary called the "gross report" (DMV 1984) contains various statistics on both apportioned-license vehicles and other commercial vehicles, including their unladen weight. These DMV data were examined to make a truck-size-specific estimate of out-of-state truck content. To develop such an estimate applicable to ARB's HDV weight classes, which are based on gross vehicle weight (GVW), the unladen weight used in DMV statistics must be translated into the corresponding GVW value.

During the special truck traffic survey described in Section 2.3, PES interviewed about a dozen drivers or owners of trucks and inquired about the laden and unladen weights of their vehicles. These weights, and other characteristics of these vehicles, are shown in Table 2-10. From the table, it is clear that there is no single direct relation between GVW and unladen weight (PES confirmed this fact through discussions with truck dealers and information published in trade journals). However, from the

Table 2-10. SAMPLE LIST OF UNLADEN WEIGHT AND GVW BY BODY TYPE

Body Type	Fuel Type	Unladen Weight (lbs)	Maximum Load (lbs)	GVW (lbs)	Weight Class
Pickup	Gas	5,800	1,800	7,600	Non-HDV
	Gas	4,800	3,700	8,500	Non-HDV
PU/Box	Gas	6,500	3,500	10,000	Light-HDV
	Gas	7,800	10,200	18,000	Medium-HDV
	Diesel	11,900	16,100	28,000	Medium-HDV
Van	Gas	8,900	5,100	14,000	Light-HDV
	Gas	11,000	11,000	22,000	Medium-HDV
Bus	Diesel	20,000	15,000	35,000	Heavy-HDV
Flatbed	Gas	12,000	23,000	35,000	Heavy-HDV
Tractor	Gas	23,000	31,000	54,000	Heavy-HDV
	Diesel	23,000	57,000	80,000	Heavy-HDV
	Diesel	23,300	56,700	80,000	Heavy-HDV
	Diesel	28,500	51,500	80,000	Heavy-HDV
	Diesel	29,800	30,200	60,000	Heavy-HDV
	Diesel	30,000	60,000	90,000	Heavy-HDV
	Diesel	31,700	28,300	60,000	Heavy-HDV

data of Table 2-10, PES has derived the approximate relation shown in Table 2-11.

Table 2-11. WEIGHT CLASSES AND RANGES OF UNLADEN AND GROSS VEHICLE WEIGHT

Weight Class (ARB)	GVW (lbs)	Unladen Weight (lbs)
Non-HDV	1 - 8,500	1 - 6,000
Light-HDV	8,500 - 14,000	6 - 9,000
Medium-HDV	14,000 - 33,000	9 - 15,000
Heavy-HDV	Over 33,000	Over 15,000

The limit of 6,000 lbs, which distinguishes between non-HDV s and HDV s, is also used in a recent CALTRANS report, "California Highway Cost Allocation and Tax Alternatives Study" (CALTRANS 1985).

By applying the above relationships to the DMV's vehicle weight distributions for total apportioned vehicles and total commercial vehicles, Table 2-12 was prepared to show how the ratio of the number of apportioned vehicles to that of all commercial vehicles varies with vehicle weight class. The ratios range from 0.4% for non-HDV s to 41% for heavy HDV s. For all HDV s, the ratio is 16.7%. Although these ratio values may suggest the likelihood of finding out-of-state trucks on California roads, they do not indicate the magnitude of the contribution of out-of-state trucks to California total truck VMT. As a matter of fact, the above DMV statistics refer to California-based trucks only. According to Ida Hom of DMV, there were 95,945 additional trucks (i.e., power units) in FY 1983-4, which were registered in other states but were permitted to operate in California through the International Registration Plan (IRP) program.

Thus, there were on one hand 63,248 California-based apportioned-license trucks which were permitted to go to other states, and on the other hand 95,945 trucks based in IRP states which were permitted to enter California. Under such a situation, it is conceivable to have a wide range of percentage contribution of out-of-state trucks to California total

Table 2-12. NUMBERS OF COMMERCIAL VEHICLES REGISTERED FOR APPORTIONED AND PRIMARY LICENSES IN CALIFORNIA
(As of April 7, 1984)

HDV Class	Unladen Weight (lbs)	Apportioned Vehicles (A)	Commercial Vehicles (B)	A/B (%)
Non-HDV	1- 6,000	1,103	2,999,534	0.4%
Light-HDV	6,000- 9,000	7,222	120,037	6.0%
Medium-HDV	9,000-15,000	16,621	158,069	10.5%
Heavy-HDV	Over 15,000	38,302	93,930	40.8%
All Vehicles		63,248	3,371,570	1.9%
All HDV		62,145	372,036	16.7%

truck VMT. As depicted in Table 2-12, such a percentage contribution of out-of-state trucks may also differ from one weight class to another. In order to obtain a weight class specific percentage contribution, an approximate relationship between a percentage contribution and a ratio of apportioned-license trucks to California commercial trucks is derived in the following paragraphs.

For trucks in a given HDV weight class, it would be reasonable to assume that an annual average mileage accumulation rate, A, is the same for California primary-license trucks, California apportioned-license trucks and out-of-state trucks. Let n_p, n_a and n_o be numbers of the above three types of trucks. Further, let f_a be a fraction of VMT by California apportioned-license trucks, which occur outside of California, and let f_o be a fraction of VMT by out-of-state trucks, which occur within California. Then, state total truck VMT is written as:

$$\begin{aligned} TVMT &= n_pA + n_aA\ (1-f_a) + n_oAf_o \\ &= (n_p + n_a)A - (n_af_a - n_of_o)A \\ &= NA\ (1 - P) \end{aligned} \qquad (2\text{-}6)$$

where

$$N = n_p + n_a$$

$$P = (n_af_a - n_of_o)/N \qquad (2\text{-}7)$$

Now, let us define a parameter, F, as

$$F = \frac{\text{Total VMT accumulated by out-of-state trucks within California}}{\text{Total VMT accumulated by California apportioned-license trucks}}$$

$$= n_of_o/n_a \qquad (2\text{-}8)$$

By using the above three equations, a fraction of state total truck VMT due to out-of-state trucks is expressed as:

$$PVMT = \frac{\text{Total VMT accumulated by out-of-state trucks within California}}{\text{State total truck VMT}}$$

$$= \frac{n_o\ A\ f_o}{NA\ (1 - P)}$$

$$= \frac{n_a\ F}{N\ (1 - P)} \qquad (2\text{-}9)$$

and

$$P = (n_a f_a - n_a F)/N$$

$$= n_a (f_a - F)/N \tag{2-10}$$

Since (n_a/N) is much less than unity (see Table 2-12) and $|f_a - F|$ is less than unity under reasonably conceivable situations, $|P|$ will be much less than unity. Therefore, Equation (2-9) can be approximated by

$$PVMT = n_a F/N \tag{2-11}$$

The approximate equation, Eq. (2-11) indicates that a percentage contribution of out-of-state trucks in a particular weight class is directly proportional to a ratio of California apportioned-license trucks to California commercial trucks in that weight class. Table 2-13 lists the percentage contributions by out-of-state trucks in each of three HDV weight classes, based on the percentages of apportioned-license trucks shown in Table 2-12. In Table 2-13, a positive valued parameter, F, is varied over a likely range, only up to 1.0, at which total miles traveled in California by out-of-state trucks equal total miles traveled both in and outside of California by all California apportioned-license trucks.

Although Table 2-13 presents a conceivable range of out-of-state truck proportions in light, medium and heavy HDVs, the table alone is not sufficient to determine what values are the most plausible for the present study. As discussed in Section 2.3.1, an analysis of the 1976 ICC Survey data has estimated the out-of-state truck contribution as 27.4% of the state total VMT by heavy trucks, which constitute a very large percentage of the heavy HDV s (see Appendix F for vehicle weight distribution). A very similar result, 22.8%, was obtained from the 1971 Survey conducted by the Institute of Transportation and Traffic Engineering (ITTE) in cooperation with Highway Patrol officers and DMV staff (Zettel and Mohr 1972). In this survey, heavy trucks were weighed and their drivers interviewed at 19 locations throughout the State. The results are summarized in Table 2-14.

Like the ICC Survey, the 1971 ITTE Survey has yielded the estimate of out-of-state truck contribution at six border stations as 22.8%. At these border stations, trucks with full California registration accounted for

Table 2-13. PERCENTAGE OF CONTRIBUTION OUT-OF-STATE HDVS FOR EACH WEIGHT CLASS

Parameter, F	Light-HDV (%)	Medium-HDV (%)	Heavy-HDV (%)	Total HDV (%)
1.00	6.0	10.5	40.8	16.7
0.90	5.4	9.5	36.7	15.0
0.80	4.8	8.4	32.6	13.4
0.70	4.2	7.4	28.6	11.7
0.66	3.9	6.9	27.0	11.1
0.57	3.4	6.0	23.3	9.5
0.50	3.0	5.3	20.4	8.4
0.40	2.4	4.2	16.3	6.7
0.30	1.8	3.2	12.2	5.0
0.20	1.2	2.1	8.2	3.3
0.10	0.6	1.1	4.1	1.7

Note: (1) The numerals underlined seem to best correspond to the out-of-state truck contents found in the 1976 ICC Survey and the 1971 ITTE Survey

(2) $F = \dfrac{\text{Total VMT accumulated by out-of-state trucks within California}}{\text{Total VMT accumulated by California apportioned-license trucks}}$

Table 2-14. PERCENTAGE OF OUT-OF-STATE TRUCKS FOUND AT NINETEEN CALIFORNIA LOCATIONS (After Zettel and Mohr 1972)

Survey Location		Number of Samples	Distribution by Type of Registration (%) Full Calif.	Apportioned Calif.	Out-of-State
BORDER STATIONS					
Oregon Border	US-101	39	25.6	56.5	17.9
Oregon Border	IS-5	68	16.2	63.2	20.6
Truckee	IS-80	132	9.1	69.0	21.9
Cajon Pass	IS-5	284	37.1	43.5	19.4
San Gorgonio Pass	IS-10	381	21.5	52.8	25.7
San Ysidro	IS-5	39	35.9	33.3	30.8
Subtotal/Average*		943	24.8	52.4	22.8
INTERIOR STATIONS					
Cottonwood	IS-5	287	30.7	56.1	13.2
Livermore	IS-580	407	69.3	28.2	2.5
Livingston	US-99	592	57.6	33.9	8.5
Sacramento	IS-80	202	31.2	56.9	11.9
San Onofre	IS-5	430	70.7	26.7	2.6
Subtotal/Average*		1,918	56.2	36.8	7.0
METROPOLITAN STATIONS					
So. San Francisco	IS-101	540	84.6	11.3	4.1
Carson	IS-405	499	74.7	18.8	6.4
San Francisco	Army St.	78	91.0	7.7	1.3
Richmond	Standard St.	160	79.4	20.6	0.0
Los Angeles	Slauson Ave.	98	81.6	9.2	9.2
Oakland	7th Street	130	74.6	18.5	6.9
Long Beach	Windham Ave.	81	87.7	9.9	2.5
San Diego	24th Street	62	64.5	29.0	6.5
Subtotal/Average*		1,648	79.8	15.4	4.8
All Stations		4,509	58.2	29.9	11.9

*Weighted average where the weight is given by the sample size.

only 25% of all trucks counted, while the remaining 75% consisted of apportioned-license California trucks and out-of-state trucks, both of which were engaged primarily in interstate commerce. Therefore, PES considers the out-of-state truck proportion at these stations (i.e., 22.8%), to represent mostly heavy HDV s as in the case of the 1976 ICC Survey.

The ITTE Survey also provides the proportions of out-of-state trucks found at five interior stations and at eight metropolitan and industrial stations. The proportions are estimated to be 7.0% for the five interior stations and 4.8% for the eight metropolitan and industrial stations. These percentages should be considered as representing the overall proportions of out-of-state trucks in the vehicle mix found in the interior corridors and in the metropolitan areas, rather than as representing the proportions of out-of-state trucks in the entire light HDV and medium HDV populations.

The ITTE Survey counted heavy trucks only, excluding pick-ups, vans and recreational vehicles, some of which are also in the HDV category. During the 1984 Special Truck Traffic Survey, PES counted HDVs separately for pick-ups, vans and recreational vehicles as well as for full-size trucks. According to this Survey (see Appendix A), PES found that 25% or more of all HDVs in urban traffic (judged by the presence of double tires on the rear axle) consisted of heavier models of pick-ups, vans and recreational vehicles. Therefore, actual proportions of out-of-state trucks in California's metropolitan areas would be somewhat lower than the ITTE Survey result of 4.8%.

Taking into account the results of all three of these surveys (i.e., 1976 ICC, 1971 ITTE and 1984 PES) and of the 1984 DMV registration data, PES estimates the relative contributions of out-of-state trucks to California truck VMT as: 27% for heavy HDVs, 6% for medium HDV's and 3% for light HDV's. These estimates of out-of-state truck contributions to state total VMT by light, medium and heavy HDVs are admittedly tentative because the ICC and ITTE Survey data were for 1976 and 1971 conditions, respectively, while the DMV data were 1984 conditions. However, the estimated percentage contributions should not be in error by more than a few percentage points, because the range of results from the three data bases is relatively small.

2.5 MOTIVE POWER

Trucks are powered by burning gasoline, diesel oil or other types of fuel such as liquefied petroleum gas (LPG). Since emissions from a truck are significantly affected by a type of fuel burned to power the vehicle, it is important to know the composition of trucks with respect to their motive power, i.e., the type of fuel burned.

To estimate the distribution of motive power among trucks operated in California, PES has analyzed two data bases: the truck usage data of the 1984 PES Questionnaire Survey (for details, see Section 5.2 and Appendices D and E); and the truck weight and fuel data of the 1981 CALTRAN Weigh Station Survey. In both survey forms used in the two surveys, data items regarding gross vehicle weight and type of fuel burned were included. Data on these two items were extracted from the original data bases and were analyzed to obtain the number frequencies of trucks powered by gasoline, diesel or other type of fuel. Since the predominant fuel type used in trucks is known to shift from gasoline to diesel as their vehicle weights increase, such number frequencies were computed for three weight classes: light ($8{,}500 < GVW \leq 14{,}000$ lbs), medium ($14{,}000 < GVW \leq 33{,}000$ lbs), and heavy ($GVW > 33{,}000$ lbs).

Table 2-15 presents a summary of the number frequencies calculated from the two data bases for three fuel types and three weight classes.

The two totally different data bases described above have yielded rather similar results of the motive power spread among trucks in each weight class: For light HDVs, the Questionnaire Survey data give 95% gasoline-powered and 5% diesel-powered vehicles while the Weigh Station Survey data give 87% gasoline-powered, 8% diesel-powered, and 5% other fuel (mostly LPG) - powered vehicles. For heavy-HDVs, the Questionnaire Survey data give 4% gasoline-powered and 95% diesel-powered vehicles. This split is quite similar to the one found in the Weigh Station Survey data -- 1% gasoline-powered and 99% diesel-powered vehicles. In medium-HDV class, the

Table 2-15. MOTIVE POWER USED IN EACH WEIGHT CLASS

Motive Power	Sample Size	HDV Weight Class Light	Medium	Heavy
1984 PES Questionnaire Survey				
Gasoline	220	95%	59%	4%
Diesel	392	5%	38%	95%
Other	10	0%	3%	1%
1981 CALTRANS Weigh Station Survey				
Gasoline	585	87%	32%	1%
Diesel	3,753	8%	64%	99%
Other	49	5%	5%	0%
1980 CEC Estimate*				
Gasoline	305**	100%	82%	5%
Diesel	979	0%	18%	95%

*As determined by PES from CEC data by assuming that light HDV s account for a half of the total fuel consumption by all HDV s in Weight Classes III through V.

**Millions of gallons consumed per year

agreement between the motive power splits derived from the two surveys data is not as good as those found in light- and heavy-HDVs. The Questionnaire Survey data indicate that gasoline-powered trucks are dominant (i.e., 59% of all vehicles in medium-HDVs) while the Weigh Station Survey data indicate the opposite trend, namely, that diesel-powered vehicles dominate over gasoline-powered vehicles (64% vs 32%).

The higher diesel percent of the Weigh Station Survey data in medium-HDV class seems to have been caused by the following facts: First, the weigh stations used in the survey are located mostly on rural major highways like interstate highways and freeways. On these highways, the percentage of diesel-powered trucks to all trucks tend to be higher than on urban highways and non-state roads. Second, trucks in the Weigh Station Survey data were classified into each weight class based on their actual loaded weight instead of their GVW. Since many trucks were loaded but not up to their GVW, some trucks classified as a medium-HDV might turn out to be a heavy-HDV if their GVW were used in the classification.

Table 2-15 also list the gasoline/diesel splits of trucks, which were estimated by the California Energy Commission (JFA 1983) from DMV registration records and statewide fuel consumption data. The CEC's estimated percentages of gasoline-powered and diesel-powered trucks are in closer agreement with the percentages estimated from the PES Questionnaire Survey data than with those from the CALTRANS Weigh Station Survey data. By considering the better agreement and the problems with the use of the Weigh Station Survey data, the estimates derived from the Questionnaire Survey data are used for the subsequent analysis of truck VMT by motive power, which are discussed in Sections 3.0 and 4.0.

3.0 VMT ESTIMATES FOR COUNTIES

While Section 2.0 described the VMT estimation methodology and the various data bases, this section, Section 3, discusses some specifics of the VMT computational procedures and various aspects of the computed VMT values and their distribution over various subcategories and subregions. Section 3.1 describes the logic flow diagrams used for calculating truck VMT on state highways and non-state roads, and for allocating the computed VMT to various subcategories (axle class, weight class, and motive power) and subregions (counties). The estimates are also differentiated for VMT by California-based trucks and out-of-state trucks, and for truck VMT in the urban areas (i.e., incorporated areas in the census statistics) vs. the rural areas (i.e., unincorporated areas) of each county.

Section 3.2 describes truck VMT estimates by axle class -- 2-axle, 3-axle, 4-axle and 5+axle, while Section 3.3 presents similar estimates by weight class -- light HDV, medium HDV and heavy HDV. VMT by out-of-state trucks is discussed in Section 3.4 while truck VMT by motive power is estimated in Section 3.5.

3.1 LOGIC FLOW DIAGRAMS FOR CALCULATING TRUCK VMT

The general methodology described in Section 2 was first reduced to three specific logic flow diagrams shown in Figure 3-1 through 3-3. Based on the logic flow diagrams, the computer program "HDV" was developed for calculating countywide VMT.

Figure 3-1 shows the logic diagram for estimating truck VMT on the so-called "state highway" network, which actually includes interstate highways, freeways and expressways as well as designated state highways in both urban and rural areas. Starting with the daily traffic data file called "AADTT", CALTRANS calculates truck VMT for every highway segment and for various jurisdictions such as counties, CALTRANS districts, and the entire state. These VMT values are then normalized by comparing the state total for all vehicles with the total derived from the TASAS data, which is based on more extensive traffic surveys, conducted in all four seasons.

PES obtained from CALTRANS the normalized daily truck VMT data for all 58 counties (see Table 2-1), and used them as the first major input (I1 in Figure 3-1) to the computer program. The data provide truck VMT by axle class, but do not show how the VMT is distributed over various types of roads. On the other hand, HPMS data do not provide VMT by axle class, but do provide VMT by functional class. Therefore, all-vehicle VMT by county and by functional class, taken from the 1982 HPMS data (CALTRANS 1983), was used as the second major input (I2 in Figure 3-1) to the computer program. The VMT data are given for a total of 15 categories in every county: 6 rural functional classes, rural area total, 6 urban functional classes, urban area total, and county total.

Since the HPMS data are for all-vehicle VMT, the data are converted in the computer program to truck VMT values by multiplying all-vehicle VMT by that truck percentage which is representative of truck percentage found in traffic, for each functional class road. The truck percentages for the first five functional classes in both rural and urban areas are given in Table 2-2. As stated earlier, the truck percentage of the sixth functional class, namely, rural local roads and urban local streets, are assumed to be zero. The truck VMT so calculated is then updated to 1983 conditions by a set of yearly VMT correction factors. These correction factors were determined by taking a ratio of 1983 statewide VMT to 1982 statewide VMT on each functional class road.

In summary, the diagram in Figure 3-1 shows that daily truck VMT on the state highway network is calculated from two major data sets and two input parameters: truck VMT by axle class (I1) from the 1983 Truck Program data; all-vehicle VMT by functional class (I2) from the 1982 HPMS data; truck percentage by functional class (P3) from the 1983 HPMS data; and yearly VMT correction factor by functional class (P4) from the 1982 and 1983 HPMS data.

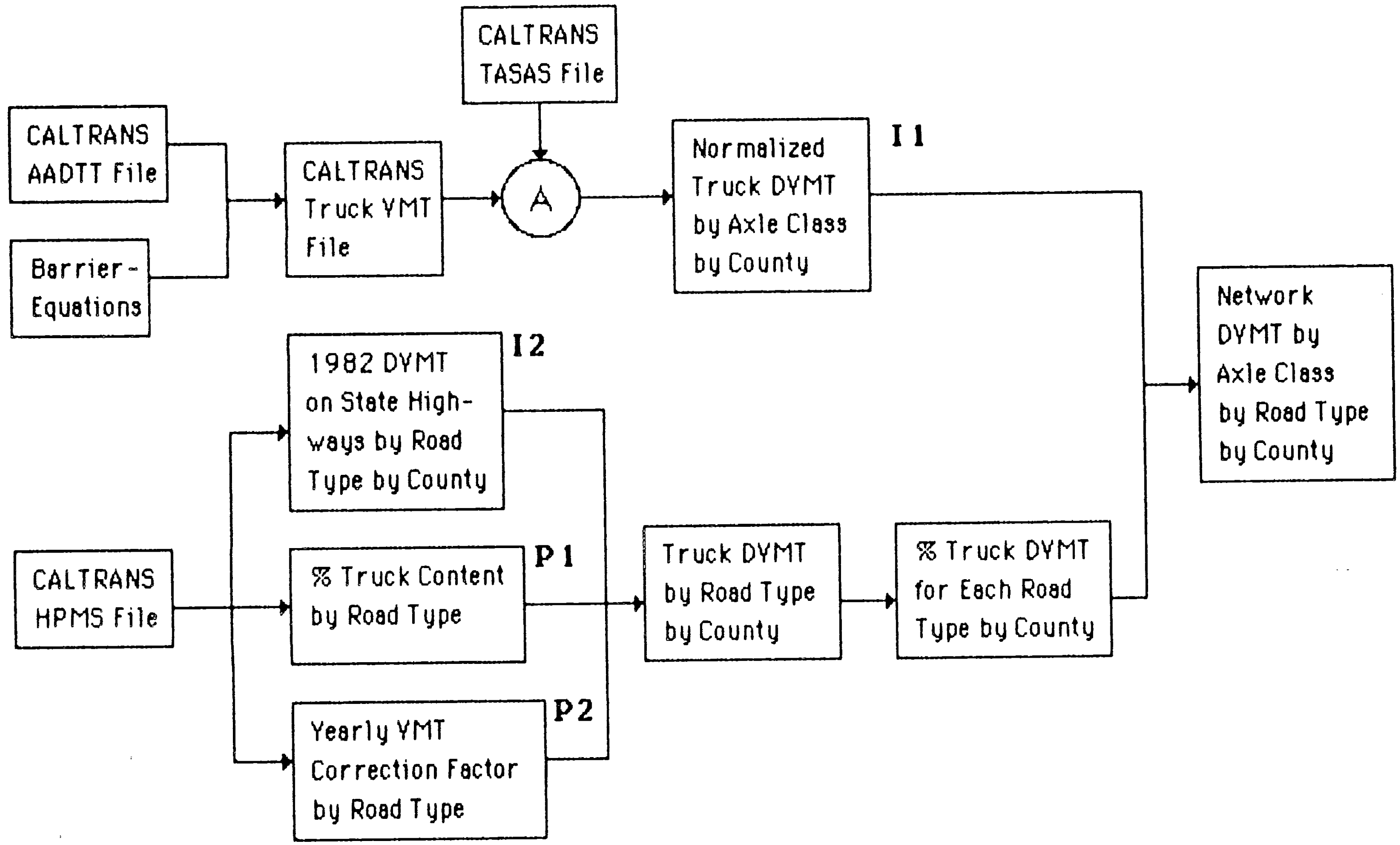
Figure 3-2 shows the logic flow diagram used for estimating truck VMT on non-state roads, that is, all roads other than state highways. (These roads are mostly under the jurisdiction of city or county governments, and thus are referred as city and county roads or non-state roads.) The upper portion of the diagram shows how truck VMT by functional class is estimated from HPMS data. The estimation method is essentially the same as for state highways.

Although the truck VMT thus estimated from the HPMS data is given for all functional classes, it is not disaggregated for each axle class. To make such a disaggregation possible, the truck mix on each functional class road is determined from results of the 1984 Special Traffic Survey and of the 1982 Classified Vehicle Survey. The resulting truck mixes for five urban functional classes and five rural functional classes are given in Table 2-7. For the sixth functional class (i.e., rural local roads and urban local streets), no attempt was made to estimate truck mix, because the truck percentage on local roads has been assumed to be zero.

Truck VMT by axle class and by functional class is estimated by the logic of Figure 3-1 for state highways and Figure 3-2 for city and county roads. Figure 3-3 shows a diagram for merging the two sets of truck VMT data into an integrated data base and, then, disaggregating it in three different ways: by weight class, by California vs. out-of-state trucks; and by motive power. These three forms of VMT estimates are useful for assessing the impact of trucks on California air quality.

The figure shows the data manipulation steps, starting with two immediate data files, network VMT and off-network VMT, and leading to three output files, designated as 01, 02, and 02. The first output is a merged data base of truck VMT on state highways and non-state roads. The second output is obtained by converting truck VMT by axle class (from file 01) to truck VMT by HDV weight class. This conversion is carried out by applying the empirical relationship given by Eqns (2-2) through (2-3).

The third output gives VMT by out-of-state trucks and VMT by motive power. VMT by out-of-state trucks is calculated by multiplying VMT by weight class (from 02) by the percentage of out-of-state trucks for each weight class (see Table 2-13). Similarly, VMT by motive power is calculated by multiplying VMT by weight class by the percentage of gasoline- and diesel- powered trucks. The percentage values used in the calculation were derived from the 1984 PES Questionnaire Survey on truck usage (see Table 2-15).



$$A = \frac{\text{TASAS DVMT for All Vehicles}}{\text{Truck Program DVMT for All Vehicles}}$$

I = Input Data Array

P = Input Parameter Array

Figure 3-1. Logic Diagram for Estimating Truck DVMT on State Highways

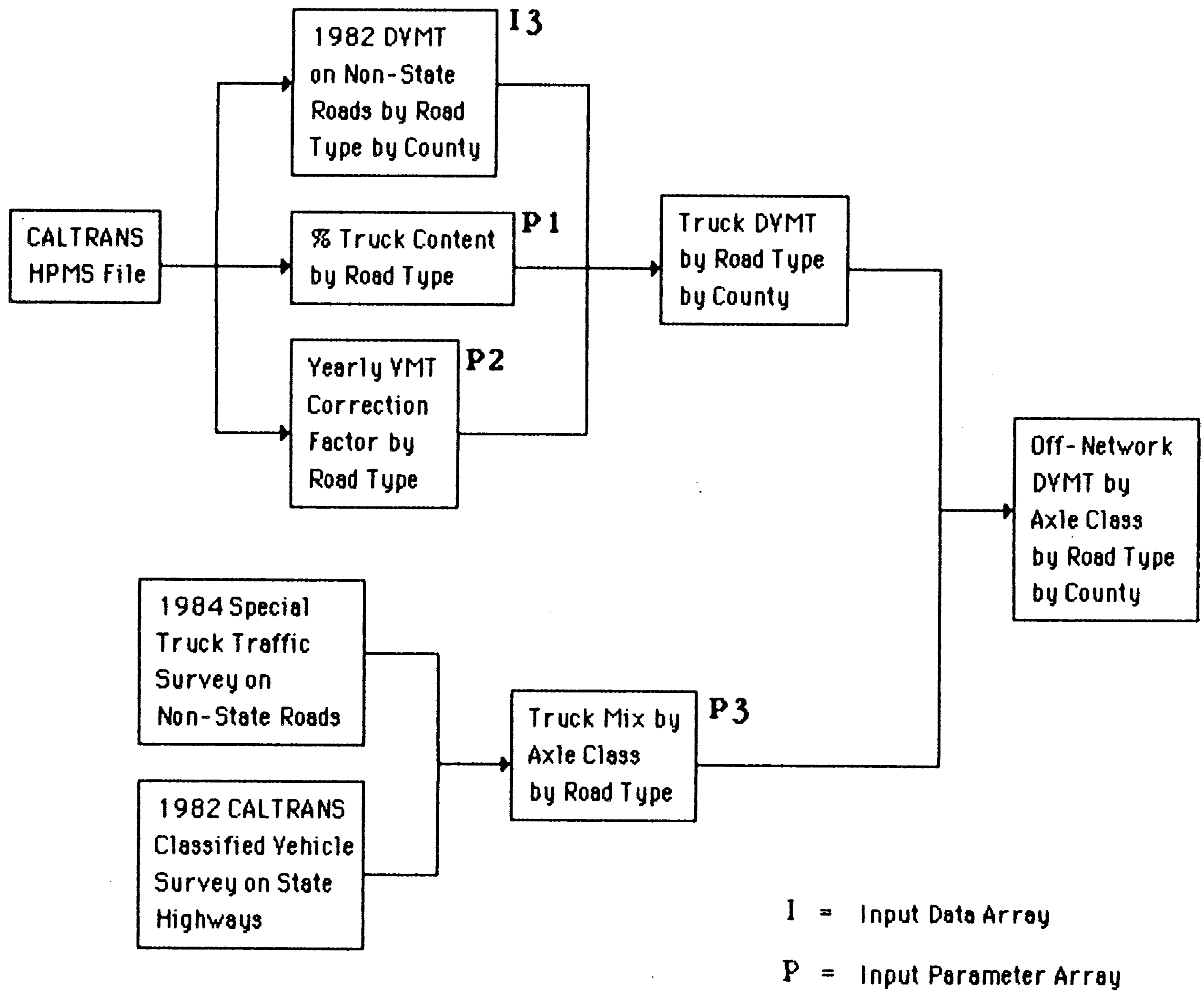


Figure 3-2. Logic Diagram for Estimating Truck DVMT on City and County Roads

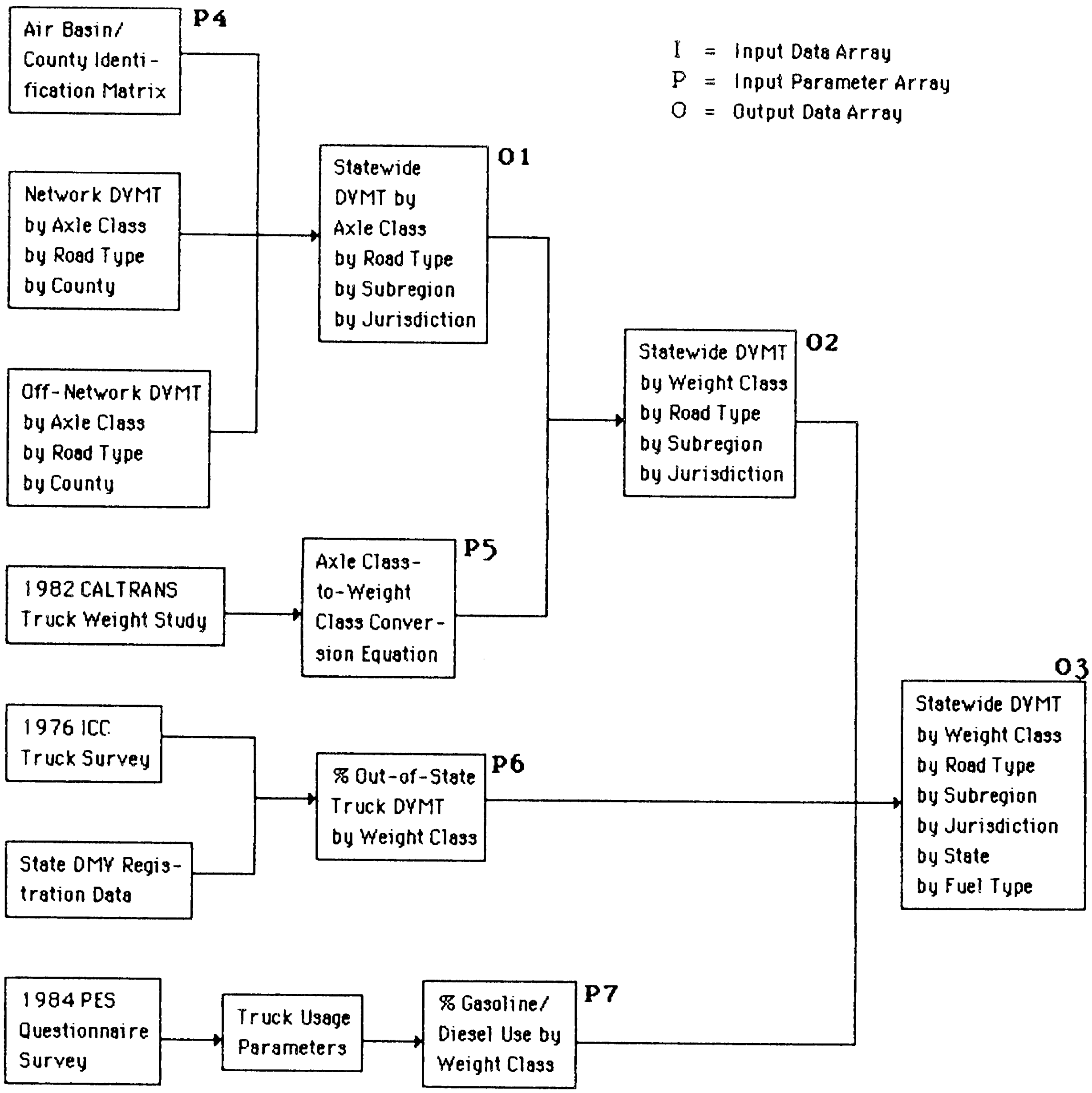


Figure 3-3. Logic Diagram for Estimating Statewide Truck DVMT

Results of the computer calculations based on the three logic flow diagrams described above are presented in the following four sections, Sections 3.2 through 3.5, and in three sections in Section 4.0.

3.2 TRUCK VMT BY AXLE CLASS

Tables 3-1 through 3-3 present annual average daily VMT (DVMT) by axle class in each county and in rural and urban portions of the county, respectively. A cursory examination of Table 3-1 indicates that truck VMT is generated mainly by 2-axle trucks in highly urbanized counties like Los Angeles, Orange, San Diego, San Francisco and San Mateo. On the other hand, VMT in moderately urbanized or rural counties with major traffic corridors seems to be dominated by 5+axle trucks. Such counties for example, are, Alameda, Fresno, Imperial, San Bernardino, Siskiyou and Yolo. Many counties along Interstate-5 are included in this type: Siskiyou, Shasta, Tehama and Yolo in the north; and San Joaquin, Stanislaus, Merced, Fresno, Kings and Kern in the south.

Table 3-2 presents truck VMT axle class in the rural portions of each county. San Francisco county has no rural roads and thus no rural VMT. It should be noted that Kern county has the greatest rural truck VMT in the state, exceeding that of Los Angeles County by a factor of two or more in 4-axles, 5+axles and total trucks.

Table 3-3 presents truck VMT by axle class in the urban portions of each county. Many rural counties like Alpine, Amador, Calaveras, Colusa and so forth have no urban areas, and thus no urban truck VMT. There are 14 such counties in the state. In terms of urban truck VMT, Los Angeles County out numbers all other counties in every axle class by a large margin. The urban truck VMT of Los Angeles county accounts for nearly 40% of the state total urban VMT.

More detailed data on truck VMT by axle class, rural/urban area, and state/non-state road are summarized in Table 3-4 for selected counties and for the entire state. Counties selected for this tabulation are: Alameda, industrial county; Butte, a rural county; Kern, a moderately urbanized county with a major traffic corridor; Los Angeles, the most populous county; and San Francisco, a highly urbanized but small county.

On a statewide basis, 36 million truck miles are driven daily on state highways and on city and county roads. Of the 36 million DVMT, 15 million (41%) occur in the rural areas and 21 million (59%) in the urban areas. State highways accommodate 69% of the truck miles and the rest is accommodated by city and county roads. These numbers should be compared to the following road mile and all-vehicle VMT statistics (SYDEC 1984): State highways comprise 9% of statewide road miles and accommodate 54% of statewide VMT; city and county roads comprise 71% of statewide mileage and carry 46% of VMT; and routes under federal ownership in national parks, forests, etc. comprise 20% of statewide mileage, but have less than 1% of statewide VMT.

As to statewide truck mix, 2-axles contribute the greatest share (46%) of statewide truck VMT, followed by 5+axles (38%), 3-Axles (12%) and 4-axles (4%). In rural areas, however, 5-axles dominate over 2-axles by a margin of 3 to 2. As mentioned earlier, 2-axles are the most prevalent in urban areas. VMT by 2-axles in urban areas accounts for 32% of statewide truck VMT.

Truck mixes in the individual counties can differ considerably from the overall truck mix of the state, reflecting the unique traffic conditions existing in particular counties. In Alameda County, which is highly industrialized, the urban traffic accounts for the great majority (82%) of countywide truck VMT and has about equal proportions of truck VMT by 2-axles (35%) and 5+axles (33%). On the other hand, in Butte County, the rural traffic accounts for the majority (73%) of the countywide truck VMT. Importance of the rural traffic is more pronounced in Kern County, which is located at the hub of several major trucking routes: Interstate-5 and state highways 99, 58 and 178. The rural traffic accounts for 85% of the countywide truck VMT and has a very high proportion of 5+axles (68%).

Los Angeles County, which is highly urbanized, has high proportions of urban truck traffic (92%) and 2-axle trucks (58%) in the countywide truck VMT. San Francisco County, with 100 percent urban truck traffic, shows an even higher proportion of 2-axle trucks (65%).

3.3 TRUCK VMT BY WEIGHT CLASS

Tables 3-5 through 3-7 present annual average daily VMT (DVMT) by HDV weight class in each county and in rural and urban portions of the county, respectively. A cursory examination of Table 3-5 reveals that in most counties, the largest proportion of VMT is contributed by the heaviest of the three weight classes, which are: light (85,000 < GVW ≤ 14,000 lbs), medium (14,000 < GVW ≤ 33,000 lbs), and heavy (GVW > 33,000 lbs). However, VMT by medium HDVs is preponderant in the following eleven counties: Amador, El Dorado, Lake, Los Angeles, Marin, Napa, Orange, San Diego, San Mateo, San Francisco, and Ventura. Only in Mariposa County is the proportion of VMT by light HDVs the greatest.

The preponderance of VMT by heavy HDV's seems to be more pronounced on rural roads than on all roads. Table 3-6 indicates that VMT by heavy HDV's is preponderant in 53 out of the 58 counties in the state. In the remaining five counties, VMT by medium HDVs is preponderant. These counties are Amador, Lake, Mariposa, Orange and San Diego.

Table 3-7 presents DVMT by weight class on urban roads in each county. Unlike the previous two tables, this table indicates that the proportion of VMT by medium HDVs is as large as or larger than that by heavy HDVs. Of the 58 counties, 23 counties have the largest VMT values in the medium weight class while 21 counties have largest VMT in the heavy weight class. The remaining 14 counties have no truck VMT on urban roads.

Table 3-8 provides details of VMT by weight class for five selected counties and for the entire state. On the statewide basis, heavy HDV's account for the largest percentage (44%) of the state total of 36 million vehicle miles per day, followed by medium HDVs (35%) and light HDVs (21%). On urban roads, however, medium HDVs contribute the most (24%) to the state total, followed by heavy HDVs (20%) and light HDVs (15%). Truck VMT on urban roads account for 59% of the state total. The remaining 41% of truck VMT occurs on rural roads.

In highly industrialized Alameda County, heavy HDVs account for most truck VMT--about half the county total--both on rural and urban roads. Truck VMT takes place primarily on urban roads (82%) and rather little on rural roads (18%). In rural Butte County, truck VMT occurs mostly on rural roads (73%), rather than on urban roads (27%). In this county, VMT by medium HDVs is about as large as that by heavy HDVs (38% vs. 39%).

Being at the hub of major trucking routes, Kern County's truck VMT is preponderantly by heavy HDV s (69%) and mostly on rural roads (85%). In contrast, truck VMT in the two urbanized counties, Los Angeles and San Francisco, take place almost completely on urban roads (92% and 100% respectively). In these counties, trucks are about evenly divided among the three weight classes, with a somewhat higher percentage for medium HDV s (42% and 47%, respectively.)

3.4 TRUCK VMT BY OUT-OF-STATE TRUCKS

Tables 3-9 and 3-10 present, respectively, estimated daily VMT by out-of-state trucks and that by California-based trucks in each of 58 counties. The VMT estimates are given for each of three weight class as well as for all trucks. A cursory comparison of VMT values in the two tables indicates that out-of-state truck VMT tends to be the largest in the heavy HDV class while California-based truck VMT tends to be distributed rather evenly over all three weight classes.

Table 3-11 was prepared to examine the above observation in more detail. The table shows that on a statewide basis, heavy HDV s account for 81% of the state total VMT by out-of-state trucks, which is estimated to be 5.3 million vehicle miles per day, or about 15% of the state total VMT by all trucks. In contrast to the high proportion of heavy HDV s in out-of-state trucks, VMT by California-based trucks is distributed more evenly over all three weight classes: 24% by light HDVs, 38% by medium HDVs and 38% by heavy HDV s.

Among the five counties listed in Table 3-11, Kern County has the highest proportion of VMT contributed by heavy HDVs among out-of-state trucks (93%). In this county, California-based heavy HDV s also account for a quite high percentage (64%) of countywide VMT by all California-based trucks. San Francisco County has the lowest proportion of VMT by heavy HDV s both for out-of-state trucks and for California-based trucks, viz., 63% and 19%, respectively. Among California-based trucks, San Francisco

County has quite high proportions of VMT by light HDV s (32%) and by medium HDV s (49%).

Table 3-12 and 3-13 show the numbers of daily VMT on rural roads and urban roads, for California-based trucks and for out-of-state trucks, respectively. A common feature in the two tables is that many rural counties have either no urban road or rather few urban truck VMT compared to their rural VMT values. In addition to the fact that VMT by out-of-state trucks is about an order of magnitude smaller than VMT by California-based trucks, Tables 3-12 and 3-13 seem to indicate that the proportion of VMT by out-of-state trucks to VMT by all trucks, on rural roads, tends to be larger than that on urban roads.

Table 3-14 was prepared to examine the above observation in more detail. On a statewide basis, out-of-state trucks account for 18% of all truck VMT on rural roads, 13% on urban roads and 15% for all roads. These values certainly support the above observation. It should also be noted that out-of-state truck VMT values on rural and urban roads are about equal, while California-based truck VMT on urban roads is about 50% larger than that on rural roads. Among the five counties listed in the table, Kern County has the highest proportion of out-of-state truck VMT (20%) while San Francisco County has the lowest proportion. This is consistent with what has been observed on out-of-state truck VMT on urban and rural roads. San Francisco County has only urban roads on which out-of-state truck content is lower while Kern County has many rural road miles and major trucking routes, both of which have exhibited a higher out-of-state truck content.

3.5 TRUCK VMT BY MOTIVE POWER

Almost all trucks are powered by burning gasoline, diesel oil or liquefied petroleum gas (LPG). Light HDV s are mostly powered by gasoline, while heavy HDV s are mostly powered by diesel oil. Trucks powered by LPG or other fuel are rather rare in all three weight classes (light, medium and heavy.) Tables 3-15 and 3-16 present estimated DVMT by motive power for California-based trucks and for out-of-state trucks, respectively.

Table 3-15 (for California-based trucks) seems to indicate that VMT by gasoline-powered trucks and by diesel-powered trucks are roughly equal on a statewide basis, with some variation from county to county. On the other hand, Table 3-16 indicates that, for out-of-state vehicles, VMT by diesel-powered trucks is greater than that by gasoline-powered trucks in every county. Table 3-17 shows the differences in motive power between California-based trucks and out-of-state trucks. For California-based vehicles, gasoline-powered trucks and diesel-powered trucks account for, respectively, 47% and 52% of state total DVMT of 31 million vehicle miles per day. For out-of-state vehicles, diesel-powered trucks account for 83% of the state total DVMT of 5 million vehicle miles per day.

Among the five counties listed in Table 3-17, Kern County exhibits the greatest relative contributions from diesel-powered trucks to the county total VMT values: 70% for California-based trucks and 90% for out-of-state trucks. At the other extreme, San Francisco County has the smallest diesel-powered (i.e., the largest gasoline-powered) truck contributions: 38% of the county total VMT by California-based trucks and 71% of the county total VMT by out-of-state trucks. In all five counties, trucks powered by other types of fuel account for only 1 or 2% of county total VMT. For VMT by out-of-state trucks, diesel-powered trucks account for 70% or more, indicating that the great majority of the out-of-state trucks in California are powered by diesel oil.

Table 3-18 presents truck DVMT by motive power for rural roads while Table 3-19 does the same for urban roads. Truck VMT on rural roads appears to be dominated by diesel-powered trucks in nearly all counties. The ratio of diesel-powered trucks to gasoline-powered trucks on rural roads is about 2 to 1 in most counties. On urban roads, however, VMT by gasoline-powered trucks is as large as VMT by diesel-powered trucks in many counties and is even slightly greater in urbanized counties such as Los Angeles, San Diego and San Francisco.

Table 3-20 presents a more detailed distribution of truck DVMT by motive power between rural and urban roads. On a statewide basis, urban roads provide more VMT than rural roads (59% vs. 41%) and diesel-powered trucks yield more VMT than gasoline-powered trucks (56% vs. 42%). A VMT ratio of diesel- to gasoline-powered trucks is about 2 to 1 on rural roads and 1 to 1 on urban roads. Trucks powered by other types of fuel account for only 1% of truck VMT on both rural and urban roads.

Among the five counties listed in Table 3-20, Kern County has the highest diesel contribution (74%) to county total VMT while San Francisco County has the lowest contribution (42%). This is understandable because Kern County has the highest proportion of truck VMT on rural roads, which are characterized by a high diesel-truck content. Conversely, San Francisco County has nothing but urban roads which are characterized by a high gasoline-truck content. Alameda County has the second highest diesel-contribution among the five counties. This county is unique in that diesel-powered trucks have a higher proportion than gasoline-powered trucks on urban roads as well as on rural roads. This is probably due to the fact that the county is highly industrial and that heavy HDV s form the largest class both on rural and urban roads (see Table 3-8).

Table 3-1. ANNUAL AVERAGE DAILY TRUCK VMT BY AXLE CLASS IN EACH COUNTY

REGION	2-AXLES	3-AXLES	4-AXLES	5+AXLES
ALAMEDA	596,225	180,353	53,456	617,119
ALPINE	2,540	592	90	1,869
AMADOR	21,206	6,662	729	13,703
BUTTE	112,007	29,579	7,514	72,402
CALAVERAS	18,732	5,727	737	14,090
COLUSA	33,075	9,692	5,923	115,380
CONTRA COSTA	324,055	86,551	23,402	266,231
DEL NORTE	17,840	7,704	1,549	22,396
EL DORADO	77,501	17,997	4,108	45,784
FRESNO	394,127	90,219	47,939	568,683
GLENN	27,144	8,308	4,501	103,636
HUMBOLDT	81,278	49,292	8,240	95,662
IMPERIAL	111,349	23,047	11,080	181,151
INYO	45,667	9,641	7,263	42,614
KERN	474,147	119,703	81,378	1,241,900
KINGS	66,786	17,659	9,316	154,437
LAKE	31,665	7,172	2,610	12,818
LASSEN	53,422	20,736	7,544	40,925
LOS ANGELES	5,172,058	1,108,737	376,952	2,220,485
MADERA	64,883	15,033	7,690	182,988
MARIN	119,451	29,046	5,623	59,707
MARIPOSA	8,760	1,180	286	2,406
MENDOCINO	82,883	36,642	9,596	80,272
MERCED	116,138	40,686	19,364	342,324
MODOC	18,385	6,656	2,678	13,686
MONO	14,988	5,828	5,843	13,788
MONTEREY	224,490	58,277	23,632	209,329
NAPA	51,979	13,786	3,150	28,069
NEVADA	57,683	14,305	5,161	68,918
ORANGE	1,423,011	298,755	113,938	547,649
PLACER	124,615	42,390	11,772	159,266
PLUMAS	22,355	7,780	2,864	19,544
RIVERSIDE	757,687	168,005	80,831	878,823
SACRAMENTO	506,904	129,900	34,356	375,490
SAN BENITO	36,836	7,099	3,280	37,960
SAN BERNARDIN	715,995	225,314	134,320	930,494
SAN DIEGO	1,217,085	246,515	77,640	423,509
SAN FRANCISCO	203,087	45,986	10,949	52,367
SAN JOAQUIN	248,963	77,857	27,430	448,433
SAN LUIS OBIS	152,076	36,957	16,691	141,262
SAN MATEO	320,193	82,523	22,297	148,646
SANTA BARBARA	188,501	49,298	19,308	164,219
SANTA CLARA	748,828	209,645	58,762	528,820
SANTA CRUZ	102,748	27,295	4,538	54,215
SHASTA	132,277	50,963	21,964	192,853
SIERRA	7,248	5,167	839	14,013
SISKIYOU	73,494	66,490	19,153	215,571
SOLANO	149,800	52,541	17,659	235,325
SONOMA	172,112	52,515	10,351	148,391
STANISLAUS	156,810	44,094	12,607	185,537
SUTTER	40,654	9,505	3,434	43,797
TEHAMA	59,402	20,973	8,515	130,622
TRINITY	12,483	8,364	1,100	14,888
TULARE	213,486	51,996	21,793	502,031
TUOLUMNE	29,597	8,626	1,491	20,481
VENTURA	379,895	95,208	35,523	189,557
YOLO	90,515	25,748	9,041	171,231
YUBA	32,479	8,739	2,094	29,015

Table 3-2. ANNUAL AVERAGE DAILY TRUCK VMT BY AXLE CLASS IN RURAL AREAS

REGION	2-AXLES	3-AXLES	4-AXLES	5+AXLES
ALAMEDA	86,578	31,441	11,038	138,181
ALPINE	2,540	592	90	1,869
AMADOR	21,206	6,662	729	13,703
BUTTE	74,626	20,897	5,879	59,545
CALAVERAS	18,732	5,727	737	14,090
COLUSA	33,075	9,692	5,923	115,380
CONTRA COSTA	38,133	10,760	3,606	40,612
DEL NORTE	17,840	7,704	1,549	22,396
EL DORADO	60,088	14,242	3,502	40,205
FRESNO	228,912	54,970	35,868	445,305
GLENN	27,144	8,308	4,501	103,636
HUMBOLDT	61,623	40,510	6,862	81,413
IMPERIAL	98,167	20,385	10,282	169,918
INYO	45,667	9,641	7,263	42,614
KERN	362,620	94,737	71,075	1,106,354
KINGS	57,098	15,646	8,964	151,370
LAKE	31,665	7,172	2,610	12,818
LASSEN	51,005	20,020	7,351	39,983
LOS ANGELES	373,258	83,478	35,428	230,275
MADERA	58,463	13,645	7,217	172,698
MARIN	26,136	6,892	1,631	19,081
MARIPOSA	8,760	1,180	286	2,406
MENDOCINO	74,684	34,263	9,092	76,774
MERCED	99,551	36,216	17,834	318,886
MODOC	18,385	6,656	2,678	13,686
MONO	14,938	5,818	5,842	13,782
MONTEREY	150,147	41,032	18,545	169,273
NAPA	33,753	9,550	2,427	22,812
NEVADA	51,147	12,882	4,858	65,674
ORANGE	113,897	24,875	12,131	64,989
PLACER	88,991	32,644	9,537	133,817
PLUMAS	22,355	7,780	2,864	19,544
RIVERSIDE	461,758	104,888	57,290	638,874
SACRAMENTO	84,584	25,881	8,782	111,540
SAN BENITO	33,832	6,527	3,052	35,364
SAN BERNARDIN	384,086	134,531	91,136	641,917
SAN DIEGO	192,901	39,711	16,655	101,414
SAN FRANCISCO	0	0	0	0
SAN JOAQUIN	160,331	55,599	21,664	371,403
SAN LUIS OBIS	112,032	27,864	13,576	116,580
SAN MATEO	37,878	10,689	3,447	24,508
SANTA BARBARA	99,149	27,837	12,527	110,734
SANTA CLARA	64,087	22,338	7,384	82,883
SANTA CRUZ	46,650	13,737	2,522	34,260
SHASTA	99,809	40,453	18,198	161,289
SIERRA	7,248	5,167	839	14,013
SISKIYOU	70,891	64,442	18,592	209,317
SOLANO	65,669	26,813	10,043	140,321
SONOMA	105,296	34,702	7,504	112,087
STANISLAUS	95,974	29,811	9,651	151,735
SUTTER	29,059	7,049	2,913	38,868
TEHAMA	53,492	19,328	8,028	123,791
TRINITY	12,483	8,364	1,100	14,888
TULARE	167,204	41,836	19,042	447,695
TUOLUMNE	29,597	8,626	1,491	20,481
VENTURA	112,672	30,659	13,602	75,647
YOLO	60,091	18,173	6,993	136,412
YUBA	20,033	5,634	1,529	21,228

Table 3-3. ANNUAL AVERAGE DAILY TRUCK VMT BY AXLE CLASS IN URBAN AREAS

REGION	2-Axles	3-Axles	4-Axles	5+Axles
ALAMEDA	509,647	148,912	42,419	478,938
ALPINE	0	0	0	0
AMADOR	0	0	0	0
BUTTE	37,382	8,682	1,634	12,857
CALAVERAS	0	0	0	0
COLUSA	0	0	0	0
CONTRA COSTA	285,923	75,791	19,795	225,619
DEL NORTE	0	0	0	0
EL DORADO	17,413	3,755	606	5,579
FRESNO	165,215	35,249	12,071	123,378
GLENN	0	0	0	0
HUMBOLDT	19,654	8,782	1,378	14,249
IMPERIAL	13,182	2,662	799	11,234
INYO	0	0	0	0
KERN	111,527	24,967	10,303	135,547
KINGS	9,688	2,013	351	3,067
LAKE	0	0	0	0
LASSEN	2,418	716	193	942
LOS ANGELES	4,798,800	1,025,260	341,524	1,990,210
MADERA	6,420	1,388	473	10,290
MARIN	93,315	22,155	3,992	40,626
MARIPOSA	0	0	0	0
MENDOCINO	8,199	2,379	504	3,498
MERCED	16,586	4,470	1,529	23,438
MODOC	0	0	0	0
MONO	49	10	1	6
MONTEREY	74,343	17,245	5,088	40,056
NAPA	18,226	4,236	723	5,257
NEVADA	6,537	1,423	303	3,244
ORANGE	1,309,115	273,881	101,807	482,660
PLACER	35,624	9,746	2,235	25,449
PLUMAS	0	0	0	0
RIVERSIDE	295,929	63,117	23,542	239,948
SACRAMENTO	422,320	104,019	25,574	263,950
SAN BENITO	3,004	573	228	2,597
SAN BERNARDIN	331,909	90,782	43,185	288,577
SAN DIEGO	1,024,184	206,804	60,985	322,095
SAN FRANCISCO	203,087	45,986	10,949	52,367
SAN JOAQUIN	88,632	22,258	5,765	77,030
SAN LUIS OBIS	40,045	9,092	3,115	24,682
SAN MATEO	282,315	71,834	18,850	124,138
SANTA BARBARA	89,352	21,461	6,781	53,485
SANTA CLARA	684,740	187,308	51,378	445,937
SANTA CRUZ	56,098	13,559	2,016	19,955
SHASTA	32,469	10,510	3,765	31,564
SIERRA	0	0	0	0
SISKIYOU	2,603	2,047	560	6,254
SOLANO	84,131	25,728	7,616	95,004
SONOMA	66,816	17,813	2,848	36,305
STANISLAUS	60,836	14,283	2,957	33,803
SUTTER	11,595	2,456	521	4,929
TEHAMA	5,909	1,645	488	6,831
TRINITY	0	0	0	0
TULARE	46,282	10,160	2,751	54,336
TUOLUMNE	0	0	0	0
VENTURA	267,222	64,549	21,921	113,910
YOLO	30,424	7,576	2,047	34,818
YUBA	12,447	3,105	565	7,787

Table 3-4. ANNUAL AVERAGE DAILY TRUCK VMT BY AXLE CLASS IN SELECTED COUNTIES
(All Values in 1,000's)

County/Subarea	2-Axles[a]	(%)	3-Axles[b]	(%)	4-Axles[c]	(%)	5+Axles[d]	(%)	State Highways[e]	(%)	Non-State Roads[f]	(%)	Total(%)
ALAMEDA	596	(41)	180	(12)	53	(4)	617	(43)	1,083	(75)	364	(25)	1,447*(100)
Rural Area[g]	87	(6)	31	(2)	11	(1)	138	(10)	250	(17)	17	(1)	267(18)
Urban[h]	510	(35)	149	(10)	42	(3)	479	(33)	832	(57)	347	(24)	1,180(82)
BUTTE	112	(50)	30	(14)	8	(4)	72	(32)	115	(52)	108	(49)	222*(100)
Rural Area	75	(34)	21	(9)	6	(3)	60	(27)	93	(42)	68	(31)	162(73)
Urban Area	37	(17)	9	(4)	2	(1)	13	(6)	21	(9)	40	(18)	61(27)
KERN	474	(25)	120	(6)	81	(4)	1,242	(65)	1,708	(89)	209	(11)	1,917*(100)
Rural Area	363	(19)	95	(5)	71	(4)	1,106	(58)	1,532	(80)	102	(5)	1,634(85)
Urban Area	112	(6)	25	(1)	10	(1)	136	(7)	176	(9)	107	(6)	282(15)
LOS ANGELES	5,172	(58)	1,109	(12)	376	(4)	2,220	(25)	5,538	(62)	3,340	(38)	8,878*(100)
Rural Area	373	(4)	84	(1)	35	(0)	230	(3)	552	(6)	170	(2)	722(8)
Urban Area	4,799	(54)	1,025	(12)	342	(4)	1,990	(22)	4,986	(56)	3,170	(36)	8,156(92)
SAN FRANCISCO	203	(65)	46	(15)	11	(4)	52	(17)	134	(43)	179	(57)	312*(100)
Rural Area	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0	(0)	0(0)
Urban Area	203	(65)	46	(15)	11	(4)	52	(17)	134	(43)	179	(57)	312(100)
STATE TOTAL	16,664	(46)	4,157	(12)	1,514	(4)	13,688	(38)	24,950	(69)	11,078	(31)	36,029*)100)
Rural Area	4,998	(14)	1,489	(4)	669	(2)	7,724	(21)	12,465	(35)	2,421	(7)	14,886(41)
Urban Area	11,666	(32)	2,668	(7)	846	(2)	5,964	(17)	12,485	(35)	8,658	(24)	21,143(59)

Note: (1) a + b + c + d = e + f = row total, and g + h = regional total

(2) Due to round-off, the sum of elements may not equal the total

(3) The numeral with * is used to compute the percentages of elements to the total

Table 3-5. ANNUAL AVERAGE DAILY TRUCK VMT BY WEIGHT CLASS IN EACH COUNTY

REGION	LIGHT	MEDIUM	HEAVY	TOTAL
ALAMEDA	268,301	471,811	707,041	1,447,025
ALPINE	1,143	1,841	2,107	5,067
AMADOR	9,543	16,567	16,190	42,305
BUTTE	50,403	84,789	86,310	222,358
CALAVERAS	8,429	14,555	16,302	39,227
COLUSA	14,884	26,930	122,256	165,789
CONTRA COSTA	145,825	246,539	307,876	700,178
DEL NORTE	8,028	15,715	25,745	49,215
EL DORADO	34,875	56,579	53,935	145,318
FRESNO	177,357	295,743	627,867	1,100,732
GLENN	12,215	22,230	109,144	143,536
HUMBOLDT	36,575	81,926	115,970	235,085
IMPERIAL	50,107	81,031	195,489	327,039
INYO	20,550	34,262	50,372	105,022
KERN	213,366	371,428	1,332,334	1,916,577
KINGS	30,054	52,168	165,976	248,148
LAKE	14,249	23,298	16,719	54,225
LASSEN	24,040	46,387	52,200	122,488
LOS ANGELES	2,327,426	3,745,142	2,805,664	8,878,402
MADERA	29,197	48,746	192,650	270,489
MARIN	53,753	87,886	72,189	213,782
MARIPOSA	3,942	5,739	2,952	12,569
MENDOCINO	37,297	74,402	97,694	209,203
MERCED	52,262	98,746	367,503	518,404
MODOC	8,273	15,654	17,477	41,326
MONO	6,744	14,251	19,451	40,300
MONTEREY	101,021	172,062	242,646	515,560
NAPA	23,390	39,279	34,316	96,930
NEVADA	25,958	43,442	76,668	149,719
ORANGE	640,355	1,029,385	713,614	2,382,817
PLACER	56,077	102,096	179,871	340,049
PLUMAS	10,060	18,687	23,797	52,482
RIVERSIDE	340,959	561,006	983,381	1,885,401
SACRAMENTO	228,107	381,065	437,479	1,046,355
SAN BENITO	16,576	26,312	42,288	85,172
SAN BERNARDIN	322,198	595,843	1,088,083	2,005,518
SAN DIEGO	547,688	867,579	549,482	1,964,405
SAN FRANCISCO	91,389	147,501	73,498	312,375
SAN JOAQUIN	112,033	200,481	490,168	804,645
SAN LUIS OBIS	68,434	115,020	163,532	346,810
SAN MATEO	144,087	241,230	188,342	573,515
SANTA BARBARA	84,826	144,556	191,944	422,257
SANTA CLARA	336,972	577,998	631,084	1,545,916
SANTA CRUZ	46,237	77,116	65,444	188,718
SHASTA	59,525	115,675	222,858	397,976
SIERRA	3,261	7,880	16,125	27,267
SISKIYOU	33,072	93,285	248,350	374,599
SOLANO	67,410	124,996	262,919	455,165
SONOMA	77,450	134,838	171,081	383,217
STANISLAUS	70,565	121,272	207,213	398,975
SUTTER	18,294	30,146	48,949	97,345
TEHAMA	26,731	50,162	142,619	219,468
TRINITY	5,617	13,083	18,135	36,829
TULARE	96,069	161,006	532,231	788,958
TUOLUMNE	13,318	22,808	24,068	60,147
VENTURA	170,953	287,310	241,920	700,037
YOLO	40,732	70,790	185,012	296,458
YUBA	14,616	24,672	33,040	72,304

Table 3-6. ANNUAL AVERAGE DAILY TRUCK VMT BY WEIGHT CLASS IN RURAL AREAS

REGION	LIGHT	MEDIUM	HEAVY	TOTAL
ALAMEDA	38,960	73,269	155,009	267,208
ALPINE	1,143	1,841	2,107	5,067
AMADOR	9,543	16,567	16,190	42,305
BUTTE	33,582	57,612	69,753	161,646
CALAVERAS	8,429	14,555	16,302	39,227
COLUSA	14,884	26,930	122,256	165,789
CONTRA COSTA	17,160	29,695	46,256	93,103
DEL NORTE	8,028	15,715	25,745	49,215
EL DORADO	27,040	44,174	46,824	117,975
FRESNO	103,010	176,217	485,827	764,868
GLENN	12,215	22,230	109,144	143,536
HUMBOLDT	27,731	64,514	98,163	190,931
IMPERIAL	44,175	71,654	182,922	299,137
INYO	20,550	34,262	50,372	105,022
KERN	163,179	289,211	1,182,395	1,634,291
KINGS	25,694	45,314	162,070	233,029
LAKE	14,249	23,298	16,719	54,225
LASSEN	22,952	44,492	50,914	118,222
LOS ANGELES	167,966	275,418	279,055	722,456
MADERA	26,308	44,088	181,627	251,924
MARIN	11,761	19,737	22,242	53,727
MARIPOSA	3,942	5,739	2,952	12,569
MENDOCINO	33,608	68,060	93,145	194,630
MERCED	44,798	85,990	341,700	472,388
MODOC	8,273	15,654	17,477	41,326
MONO	6,722	14,216	19,441	40,233
MONTEREY	67,566	117,423	194,008	378,859
NAPA	15,189	26,050	27,304	68,498
NEVADA	23,016	38,751	72,793	138,046
ORANGE	51,253	84,058	80,579	215,831
PLACER	40,046	74,943	150,000	266,692
PLUMAS	10,060	18,687	23,797	52,482
RIVERSIDE	207,791	346,294	708,725	1,262,850
SACRAMENTO	38,063	67,536	125,189	230,697
SAN BENITO	15,225	24,184	39,367	78,771
SAN BERNARDIN	172,839	335,494	743,338	1,251,244
SAN DIEGO	86,806	139,390	124,486	350,600
SAN FRANCISCO	0	0	0	0
SAN JOAQUIN	72,149	134,251	402,597	610,640
SAN LUIS OBIS	50,414	85,602	134,035	269,907
SAN MATEO	17,045	29,453	30,025	76,499
SANTA BARBARA	44,617	78,152	127,478	250,888
SANTA CLARA	28,839	53,321	94,532	176,668
SANTA CRUZ	20,992	36,105	40,070	97,118
SHASTA	44,914	89,217	185,618	319,682
SIERRA	3,261	7,880	16,125	27,267
SISKIYOU	31,901	90,235	241,107	363,138
SOLANO	29,551	58,201	155,094	242,748
SONOMA	47,383	84,681	127,525	259,476
STANISLAUS	43,188	76,838	167,144	287,109
SUTTER	13,077	21,878	42,935	77,849
TEHAMA	24,071	45,599	134,967	204,596
TRINITY	5,617	13,083	18,135	36,829
TULARE	75,242	127,531	473,004	675,466
TUOLUMNE	13,318	22,808	24,068	60,147
VENTURA	50,703	87,919	93,958	232,519
YOLO	27,041	48,079	146,550	221,608
YUBA	9,015	15,466	23,942	48,407

Table 3-7. ANNUAL AVERAGE DAILY TRUCK VMT BY WEIGHT CLASS IN URBAN AREAS

REGION	LIGHT	MEDIUM	HEAVY	TOTAL
ALAMEDA	229,341	398,543	552,032	1,179,817
ALPINE	0	0	0	0
AMADOR	0	0	0	0
BUTTE	16,822	27,176	16,556	60,712
CALAVERAS	0	0	0	0
COLUSA	0	0	0	0
CONTRA COSTA	128,665	216,844	261,619	607,075
DEL NORTE	0	0	0	0
EL DORADO	7,836	12,405	7,111	27,343
FRESNO	74,347	119,526	142,040	335,864
GLENN	0	0	0	0
HUMBOLDT	8,844	17,412	17,807	44,154
IMPERIAL	5,932	9,377	12,567	27,901
INYO	0	0	0	0
KERN	50,187	82,216	149,940	282,286
KINGS	4,360	6,854	3,906	15,119
LAKE	0	0	0	0
LASSEN	1,088	1,895	1,287	4,266
LOS ANGELES	2,159,460	3,469,725	2,526,609	8,155,947
MADERA	2,889	4,659	11,023	18,565
MARIN	41,992	68,149	49,947	160,056
MARIPOSA	0	0	0	0
MENDOCINO	3,690	6,341	4,550	14,574
MERCED	7,464	12,756	25,803	46,016
MODOC	0	0	0	0
MONO	22	35	10	67
MONTEREY	33,455	54,639	48,638	136,701
NAPA	8,202	13,228	7,012	28,432
NEVADA	2,942	4,691	3,874	11,673
ORANGE	589,102	945,326	633,035	2,166,985
PLACER	16,031	27,153	29,870	73,357
PLUMAS	0	0	0	0
RIVERSIDE	133,168	214,712	274,656	622,551
SACRAMENTO	190,044	313,529	312,290	815,658
SAN BENITO	1,352	2,128	2,921	6,401
SAN BERNARDIN	149,359	260,349	344,745	754,275
SAN DIEGO	460,883	728,189	424,996	1,613,805
SAN FRANCISCO	91,389	147,501	73,498	312,375
SAN JOAQUIN	39,884	66,230	87,570	194,004
SAN LUIS OBIS	18,020	29,417	29,497	76,903
SAN MATEO	127,042	211,777	158,318	497,017
SANTA BARBARA	40,209	66,404	64,466	171,369
SANTA CLARA	308,133	524,677	536,552	1,369,248
SANTA CRUZ	25,244	41,010	25,374	91,600
SHASTA	14,611	26,457	37,240	78,295
SIERRA	0	0	0	0
SISKIYOU	1,171	3,050	7,243	11,461
SOLANO	37,859	66,795	107,826	212,416
SONOMA	30,067	50,157	43,556	123,741
STANISLAUS	27,376	44,434	40,069	111,866
SUTTER	5,218	8,268	6,015	19,496
TEHAMA	2,659	4,563	7,652	14,871
TRINITY	0	0	0	0
TULARE	20,827	33,475	59,228	113,492
TUOLUMNE	0	0	0	0
VENTURA	120,250	199,391	147,962	467,518
YOLO	13,691	22,712	38,463	74,850
YUBA	5,601	9,206	9,098	23,897

Table 3-8. ANNUAL AVERAGE DAILY TRUCK VMT BY WEIGHT CLASS IN SELECTED COUNTIES
(All Values in 1,000's)

County/Subarea	Light HDV (%)	Medium HDV (%)	Heavy HDV (%)	Total (%)
ALAMEDA	268 (19)	472 (33)	707 (49)	1,447*(100)
Rural Area	39 (3)	73 (5)	155 (11)	267(18)
Urban Area	229 (16)	399 (28)	552 (38)	1,180(82)
BUTTE	50 (23)	85 (38)	86 (39)	222*(100)
Rural Area	34 (15)	58 (26)	70 (32)	162(73)
Urban Area	17 (8)	27 (12)	17 (8)	61(27)
KERN	213 (11)	371 (19)	1,332 (69)	1,917*(100)
Rural Area	163 (9)	289 (15)	1,182 (62)	1,634(85)
Urban Area	50 (3)	82 (4)	150 (8)	282(15)
LOS ANGELES	2,327 (26)	3,745 (42)	2,806 (32)	8,878*(100)
Rural Area	168 (2)	275 (3)	279 (3)	722(8)
Urban Area	2,159 (24)	3,470 (39)	2,527 (28)	8,156(92)
SAN FRANCISCO	91 (29)	148 (47)	73 (23)	312*(100)
Rural Area	0 (0)	0 (0)	0 (0)	0(0)
Urban Area	91 (29)	148 (47)	73 (23)	312(100)
STATE TOTAL	7,499 (21)	12,575 (35)	15,949 (44)	36,029*(100)
Rural Area	2,249 (6)	4,011 (11)	8,619 (24)	14,886(41)
Urban Area	5,250 (15)	8,563 (24)	7,330 (20)	21,143(59)

Note: (1) Due to round-off, the sum of elements may not equal the total
(2) The numeral with * is used to compute the percentages of elements to the total

Table 3-9. OUT-OF-STATE TRUCK DVMT BY WEIGHT CLASS AND BY COUNTY

REGION	LIGHT	MEDIUM	HEAVY	TOTAL
ALAMEDA	8,049	28,309	190,901	227,259
ALPINE	34	110	569	714
AMADOR	286	994	4,371	5,652
BUTTE	1,512	5,087	23,304	29,903
CALAVERAS	253	873	4,402	5,528
COLUSA	447	1,616	33,009	35,071
CONTRA COSTA	4,375	14,792	83,126	102,293
DEL NORTE	241	943	6,951	8,135
EL DORADO	1,046	3,395	14,563	19,004
FRESNO	5,321	17,745	169,524	192,589
GLENN	366	1,334	29,469	31,169
HUMBOLDT	1,097	4,916	31,312	37,325
IMPERIAL	1,503	4,862	52,782	59,147
INYO	616	2,056	13,601	16,273
KERN	6,401	22,286	359,730	388,417
KINGS	902	3,130	44,814	48,845
LAKE	427	1,398	4,514	6,339
LASSEN	721	2,783	14,094	17,599
LOS ANGELES	69,823	224,709	757,529	1,052,061
MADERA	876	2,925	52,015	55,816
MARIN	1,613	5,273	19,491	26,377
MARIPOSA	118	344	797	1,260
MENDOCINO	1,119	4,464	26,377	31,961
MERCED	1,568	5,925	99,226	106,718
MODOC	248	939	4,719	5,906
MONO	202	855	5,252	6,309
MONTEREY	3,031	10,324	65,514	78,869
NAPA	702	2,357	9,265	12,324
NEVADA	779	2,607	20,700	24,085
ORANGE	19,211	61,763	192,676	273,650
PLACER	1,682	6,126	48,565	56,373
PLUMAS	302	1,121	6,425	7,848
RIVERSIDE	10,229	33,660	265,513	309,402
SACRAMENTO	6,843	22,864	118,119	147,826
SAN BENITO	497	1,579	11,418	13,494
SAN BERNARDIN	9,666	35,751	293,782	339,199
SAN DIEGO	16,431	52,055	148,360	216,846
SAN FRANCISCO	2,742	8,850	19,845	31,436
SAN JOAQUIN	3,361	12,029	132,345	147,735
SAN LUIS OBIS	2,053	6,901	44,154	53,108
SAN MATEO	4,323	14,474	50,852	69,649
SANTA BARBARA	2,545	8,673	51,825	63,043
SANTA CLARA	10,109	34,680	170,393	215,182
SANTA CRUZ	1,387	4,627	17,670	23,684
SHASTA	1,786	6,940	60,172	68,898
SIERRA	98	473	4,354	4,924
SISKIYOU	992	5,597	67,054	73,644
SOLANO	2,022	7,500	70,988	80,510
SONOMA	2,324	8,090	46,192	56,606
STANISLAUS	2,117	7,276	55,947	65,341
SUTTER	549	1,809	13,216	15,574
TEHAMA	802	3,010	38,507	42,319
TRINITY	169	785	4,896	5,850
TULARE	2,882	9,660	143,703	156,245
TUOLUMNE	400	1,368	6,498	8,266
VENTURA	5,129	17,239	65,318	87,686
YOLO	1,222	4,247	49,953	55,423
YUBA	438	1,480	8,921	10,840

Table 3-10. CALIFORNIA-BASED TRUCK DVMT BY WEIGHT CLASS AND BY COUNTY

REGION	LIGHT	MEDIUM	HEAVY	TOTAL
ALAMEDA	260,252	443,503	516,140	1,219,894
ALPINE	1,109	1,730	1,538	4,377
AMADOR	9,257	15,573	11,819	36,648
BUTTE	48,891	79,701	63,006	191,599
CALAVERAS	8,177	13,682	11,901	33,759
COLUSA	14,437	25,314	89,247	128,998
CONTRA COSTA	141,450	231,746	224,749	597,946
DEL NORTE	7,787	14,772	18,794	41,353
EL DORADO	33,829	53,184	39,373	126,386
FRESNO	172,036	277,998	458,343	908,378
GLENN	11,848	20,896	79,675	112,420
HUMBOLDT	35,478	77,011	84,658	197,147
IMPERIAL	48,604	76,170	142,707	267,481
INYO	19,933	32,206	36,772	88,912
KERN	206,965	349,142	972,604	1,528,711
KINGS	29,152	49,038	121,163	199,353
LAKE	13,822	21,900	12,205	47,926
LASSEN	23,319	43,604	38,106	105,029
LOS ANGELES	2,257,603	3,520,434	2,048,134	7,826,172
MADERA	28,321	45,822	140,634	214,777
MARIN	52,140	82,613	52,698	187,451
MARIPOSA	3,824	5,394	2,155	11,373
MENDOCINO	36,178	69,938	71,317	177,433
MERCED	50,694	92,821	268,277	411,793
MODOC	8,025	14,715	12,758	35,498
MONO	6,542	13,396	14,199	34,137
MONTEREY	97,990	161,739	177,131	436,860
NAPA	22,689	36,922	25,051	84,661
NEVADA	25,179	40,836	55,967	121,982
ORANGE	621,145	967,622	520,938	2,109,704
PLACER	54,394	95,970	131,306	281,670
PLUMAS	9,758	17,566	17,372	44,696
RIVERSIDE	330,730	527,345	717,868	1,575,944
SACRAMENTO	221,264	358,201	319,360	898,825
SAN BENITO	16,079	24,733	30,870	71,682
SAN BERNARDIN	312,532	560,092	794,301	1,666,925
SAN DIEGO	531,258	815,524	401,122	1,747,904
SAN FRANCISCO	88,648	138,651	53,654	280,953
SAN JOAQUIN	108,672	188,452	357,822	654,946
SAN LUIS OBIS	66,381	108,118	119,378	293,878
SAN MATEO	139,764	226,756	137,490	504,010
SANTA BARBARA	82,281	135,882	140,119	358,283
SANTA CLARA	326,863	543,319	460,692	1,330,873
SANTA CRUZ	44,849	72,489	47,774	165,112
SHASTA	57,739	108,734	162,686	329,159
SIERRA	3,164	7,407	11,772	22,342
SISKIYOU	32,080	87,688	181,295	301,063
SOLANO	65,388	117,497	191,931	374,815
SONOMA	75,127	126,748	124,889	326,764
STANISLAUS	68,448	113,996	151,265	333,708
SUTTER	17,745	28,338	35,733	81,816
TEHAMA	25,929	47,152	104,112	177,193
TRINITY	5,449	12,298	13,238	30,985
TULARE	93,187	151,346	388,529	633,062
TUOLUMNE	12,919	21,440	17,569	51,928
VENTURA	165,824	270,072	176,602	612,497
YOLO	39,510	66,543	135,059	241,112
YUBA	14,177	23,192	24,119	61,488

Table 3-11. TRUCK DVMT BY BASE-PLATE AND BY WEIGHT CLASS IN SELECTED COUNTIES (All Values in 1,000's)

County/Base-Plate	Light (%)	Medium (%)	Heavy (%)	Total (%)
ALAMEDA				
California	260 (21)	444 (36)	151 (42)	1,220*(100)
Out-of-State	8 (4)	28 (12)	191 (84)	227*(100)
BUTTE				
California	49 (26)	80 (42)	63 (33)	192*(100)
Out-of-State	2 (7)	5 (17)	23 (77)	30* (100)
KERN				
California	207 (14)	349 (23)	973 (64)	1,529*(100)
Out-of-State	6 (2)	22 (6)	360 (93)	388*(100)
LOS ANGELES				
California	2,258 (29)	3,520 (45)	2,048 (26)	7,826*(100)
Out-of-State	70 (7)	225 (21)	758 (72)	1,052*(100)
SAN FRANCISCO				
California	89 (32)	139 (49)	54 (19)	281*(100)
Out-of-State	3 (9)	9 (28)	20 (63)	32*(100)
STATE TOTAL				
California	7,274 (24)	11,820 (38)	11,643 (38)	30,737*(100)
Out-of-State	225 (4)	754 (14)	4,307 (82)	5,286*(100)

Note: (1) Due to round-off, the sum of elements may not equal the total

(2) The numeral with * is used to compute the percentages of elements to the total

Table 3-12. CALIFORNIA-BASED TRUCK DVMT ON RURAL AND URBAN ROADS BY COUNTY

REGION	RURAL	URBAN	TOTAL
ALAMEDA	219,820	1,000,074	1,219,895
ALPINE	4,377	0	4,377
AMADOR	36,648	0	36,648
BUTTE	137,650	53,949	191,599
CALAVERAS	33,759	0	33,759
COLUSA	128,998	0	128,998
CONTRA COSTA	78,325	519,621	597,946
DEL NORTE	41,353	0	41,353
EL DORADO	101,933	24,453	126,386
FRESNO	620,218	288,160	908,378
GLENN	112,420	0	112,420
HUMBOLDT	159,201	37,945	197,147
IMPERIAL	243,738	23,742	267,481
INYO	88,912	0	88,912
KERN	1,293,291	235,421	1,528,711
KINGS	185,830	13,523	199,352
LAKE	47,926	0	47,926
LASSEN	101,253	3,776	105,029
LOS ANGELES	625,530	7,200,642	7,826,172
MADERA	199,549	15,228	214,777
MARIN	46,198	141,253	187,451
MARIPOSA	11,373	0	11,373
MENDOCINO	164,572	12,861	177,433
MERCED	373,725	38,067	411,793
MODOC	35,498	0	35,498
MONO	34,076	61	34,137
MONTEREY	317,543	119,317	436,860
NAPA	59,152	25,509	84,661
NEVADA	111,890	10,091	121,982
ORANGE	187,553	1,922,151	2,109,704
PLACER	218,791	62,879	281,670
PLUMAS	44,696	0	44,696
RIVERSIDE	1,044,443	531,501	1,575,944
SACRAMENTO	191,793	707,032	898,825
SAN BENITO	66,238	5,444	71,682
SAN BERNARDIN	1,025,654	641,270	1,666,924
SAN DIEGO	306,103	1,441,801	1,747,904
SAN FRANCISCO	0	280,953	280,953
SAN JOAQUIN	490,076	164,870	654,947
SAN LUIS OBIS	227,214	66,664	293,878
SAN MATEO	66,137	437,873	504,010
SANTA BARBARA	209,800	148,482	358,283
SANTA CLARA	147,104	1,183,769	1,330,873
SANTA CRUZ	83,553	81,559	165,112
SHASTA	262,932	66,228	329,159
SIERRA	22,342	0	22,342
SISKIYOU	291,773	9,290	301,063
SOLANO	196,592	178,223	374,815
SONOMA	218,655	108,109	326,764
STANISLAUS	236,135	97,573	333,708
SUTTER	64,592	17,224	81,816
TEHAMA	164,739	12,454	177,193
TRINITY	30,985	0	30,985
TULARE	538,157	94,905	633,062
TUOLUMNE	51,928	0	51,928
VENTURA	200,415	412,082	612,497
YOLO	178,405	62,707	241,112
YUBA	40,760	20,728	61,488

Table 3-13. OUT-OF-STATE TRUCK DVMT ON RURAL AND URBAN ROADS BY COUNTY

REGION	RURAL	URBAN	TOTAL
ALAMEDA	47,417	179,841	227,259
ALPINE	714	0	714
AMADOR	5,652	0	5,652
BUTTE	23,298	6,605	29,903
CALAVERAS	5,528	0	5,528
COLUSA	35,071	0	35,071
CONTRA COSTA	14,786	87,508	102,293
DEL NORTE	8,135	0	8,135
EL DORADO	16,104	2,899	19,004
FRESNO	144,837	47,753	192,589
GLENN	31,169	0	31,169
HUMBOLDT	31,207	6,118	37,325
IMPERIAL	55,013	4,134	59,147
INYO	16,273	0	16,273
KERN	341,495	46,922	388,417
KINGS	47,249	1,597	48,845
LAKE	6,339	0	6,339
LASSEN	17,105	494	17,599
LOS ANGELES	96,909	955,152	1,052,061
MADERA	52,474	3,342	55,816
MARIN	7,542	18,834	26,377
MARIPOSA	1,260	0	1,260
MENDOCINO	30,241	1,720	31,961
MERCED	98,762	7,956	106,718
MODOC	5,906	0	5,906
MONO	6,304	5	6,309
MONTEREY	61,455	17,414	78,869
NAPA	9,391	2,933	12,324
NEVADA	22,670	1,416	24,085
ORANGE	28,337	245,312	273,650
PLACER	46,198	10,175	56,373
PLUMAS	7,848	0	7,848
RIVERSIDE	218,367	91,035	309,402
SACRAMENTO	38,995	108,831	147,826
SAN BENITO	12,537	957	13,494
SAN BERNARDIN	226,016	113,183	339,199
SAN DIEGO	44,579	172,267	216,846
SAN FRANCISCO	0	31,436	31,436
SAN JOAQUIN	118,921	28,814	147,735
SAN LUIS OBIS	42,838	10,270	53,108
SAN MATEO	10,385	59,264	69,649
SANTA BARBARA	40,447	22,596	63,043
SANTA CLARA	29,588	185,594	215,182
SANTA CRUZ	13,615	10,069	23,684
SHASTA	56,817	12,081	68,898
SIERRA	4,924	0	4,924
SISKIYOU	71,470	2,174	73,644
SOLANO	46,254	34,256	80,510
SONOMA	40,934	15,672	56,606
STANISLAUS	51,035	14,306	65,341
SUTTER	13,297	2,277	15,574
TEHAMA	39,899	2,419	42,319
TRINITY	5,850	0	5,850
TULARE	137,620	18,625	156,245
TUOLUMNE	8,266	0	8,266
VENTURA	32,165	55,521	87,686
YOLO	43,264	12,158	55,423
YUBA	7,663	3,177	10,840

Table 3-14. CALIFORNIA-BASED AND OUT-OF-STATE TRUCK DVMT AND THEIR CONTRIBUTIONS TO TOTAL TRUCK DVMT ON RURAL AND URBAN ROADS IN SELECTED COUNTIES (All Values in 1,000's)

County/Base-Plate	Rural (%)	Urban (%)	Total (%)
ALAMEDA	267*(100)	1,180*(100)	1,447*(100)
California	220(82)	1,000(85)	1,220(84)
Out-of-State	47(18)	180(15)	227(16)
BUTTE	162*(100)	61*(100)	222*(100)
California	138(86)	54(89)	192(86)
Out-of-State	23(14)	7(11)	30(14)
KERN	1,634*(100)	282*(100)	1,917*(100)
California	1,293(79)	235(83)	1,529(80)
Out-of-State	341(21)	47(17)	388(20)
LOS ANGELES	722*(100)	8,156*(100)	8,878*(100)
California	626(87)	7,201(88)	7,826(88)
Out-of-State	97(13)	955(12)	1,052(12)
SAN FRANCISCO	0*(NA)	312*(100)	312*(100)
California	0(NA)	281(90)	281(90)
Out-of-State	0(NA)	31(10)	31(10)
STATE TOTAL	14,886*(100)	21,143*(100)	36,029*(100)
California	12,244(82)	18,493(87)	30,737(85)
Out-of-State	2,635(18)	2,650(13)	5,286(15)

Note: (1) NA: Not applicable because San Francisco County has no rural road

(2) Due to round-off, the sum of elements may not equal the total

(3) The numeral with * is used to compute the percentages of elements to the total

Table 3-15. CALIFORNIA-BASED TRUCK DVMT BY MOTIVE POWER AND BY COUNTY

REGION	GASOLINE	DIESEL	OTHER	TOTAL
ALAMEDA	529,552	671,876	18,466	1,219,894
ALPINE	2,136	2,174	67	4,377
AMADOR	18,455	17,608	585	36,648
BUTTE	95,991	92,587	3,021	191,599
CALAVERAS	16,316	16,913	529	33,759
COLUSA	32,220	95,126	1,652	128,998
CONTRA COSTA	280,098	308,648	9,200	597,946
DEL NORTE	16,865	23,857	631	41,353
EL DORADO	65,091	59,306	1,989	126,386
FRESNO	345,787	549,667	12,923	908,378
GLENN	26,772	84,224	1,424	112,420
HUMBOLDT	82,526	111,463	3,157	197,147
IMPERIAL	96,822	166,946	3,712	267,481
INYO	39,409	48,168	1,334	88,912
KERN	441,515	1,066,996	20,200	1,528,711
KINGS	61,473	135,196	2,683	199,353
LAKE	26,540	20,607	779	47,926
LASSEN	49,403	53,936	1,689	105,029
LOS ANGELES	4,303,704	3,396,373	126,094	7,826,172
MADERA	59,565	152,431	2,781	214,777
MARIN	100,383	84,063	3,005	187,451
MARIPOSA	6,901	4,288	183	11,373
MENDOCINO	78,485	96,136	2,811	177,433
MERCED	113,655	292,670	5,467	411,793
MODOC	16,816	18,113	569	35,498
MONO	14,687	18,907	544	34,137
MONTEREY	195,602	234,635	6,623	436,860
NAPA	44,340	38,963	1,358	84,661
NEVADA	50,252	69,945	1,785	121,982
ORANGE	1,181,822	893,645	34,238	2,109,704
PLACER	113,549	163,929	4,192	281,670
PLUMAS	20,329	23,666	701	44,696
RIVERSIDE	654,042	898,903	22,999	1,575,944
SACRAMENTO	434,314	450,571	13,940	898,825
SAN BENITO	31,102	39,529	1,051	71,682
SAN BERNARDIN	659,132	983,047	24,746	1,666,925
SAN DIEGO	1,001,899	717,528	28,477	1,747,904
SAN FRANCISCO	168,166	108,091	4,696	280,953
SAN JOAQUIN	228,738	416,977	9,232	654,946
SAN LUIS OBIS	131,627	157,813	4,437	293,878
SAN MATEO	272,062	223,771	8,178	504,010
SANTA BARBARA	163,942	188,863	5,478	358,283
SANTA CLARA	649,506	660,461	20,906	1,330,873
SANTA CRUZ	87,286	75,174	2,652	165,112
SHASTA	125,513	198,758	4,889	329,159
SIERRA	7,847	14,156	340	22,342
SISKIYOU	89,464	207,156	4,444	301,063
SOLANO	139,119	230,253	5,444	374,815
SONOMA	151,147	170,565	5,051	326,764
STANISLAUS	138,333	190,443	4,933	333,708
SUTTER	35,007	45,602	1,207	81,816
TEHAMA	56,617	118,121	2,456	177,193
TRINITY	12,962	17,522	501	30,985
TULARE	193,363	431,273	8,426	633,062
TUOLUMNE	25,625	25,484	819	51,928
VENTURA	323,939	278,690	9,868	612,497
YOLO	82,197	155,568	3,347	241,112
YUBA	28,116	32,435	937	61,488

Table 3-16. OUT-OF-STATE TRUCK DVMT BY MOTIVE POWER AND BY COUNTY

REGION	GASOLINE	DIESEL	OTHER	TOTAL
ALAMEDA	31,985	192,516	2,758	227,259
ALPINE	120	584	9	714
AMADOR	1,033	4,545	74	5,652
BUTTE	5,370	24,147	386	29,903
CALAVERAS	932	4,526	70	5,528
COLUSA	2,698	31,995	379	35,071
CONTRA COSTA	16,209	84,810	1,275	102,293
DEL NORTE	1,063	6,974	98	8,135
EL DORADO	3,579	15,177	247	19,004
FRESNO	22,305	168,057	2,228	192,589
GLENN	2,314	28,521	335	31,169
HUMBOLDT	5,195	31,669	461	37,325
IMPERIAL	6,408	52,066	674	59,147
INYO	2,343	13,732	198	16,273
KERN	33,619	350,532	4,266	388,417
KINGS	4,496	43,807	542	48,845
LAKE	1,411	4,841	87	6,339
LASSEN	2,891	14,483	224	17,599
LOS ANGELES	229,211	808,533	14,317	1,052,061
MADERA	4,638	50,570	608	55,816
MARIN	5,423	20,601	353	26,377
MARIPOSA	347	894	18	1,260
MENDOCINO	4,752	26,811	398	31,961
MERCED	8,954	96,594	1,170	106,718
MODOC	979	4,852	75	5,906
MONO	907	5,324	78	6,309
MONTEREY	11,591	66,313	965	78,869
NAPA	2,428	9,733	163	12,324
NEVADA	3,106	20,695	285	24,085
ORANGE	62,397	207,472	3,780	273,650
PLACER	7,155	48,549	669	56,373
PLUMAS	1,205	6,545	98	7,848
RIVERSIDE	40,197	265,540	3,665	309,402
SACRAMENTO	24,716	121,244	1,867	147,826
SAN BENITO	1,861	11,472	162	13,494
SAN BERNARDIN	42,027	293,162	4,010	339,199
SAN DIEGO	52,256	161,545	3,045	216,846
SAN FRANCISCO	8,620	22,352	464	31,436
SAN JOAQUIN	15,584	130,467	1,684	147,735
SAN LUIS OBIS	7,788	44,671	649	53,108
SAN MATEO	14,680	54,026	943	69,649
SANTA BARBARA	9,608	52,657	778	63,043
SANTA CLARA	36,881	175,557	2,744	215,182
SANTA CRUZ	4,754	18,614	316	23,684
SHASTA	8,198	59,890	810	68,898
SIERRA	546	4,321	58	4,924
SISKIYOU	6,927	65,878	838	73,644
SOLANO	9,186	70,390	935	80,510
SONOMA	8,828	47,073	705	56,606
STANISLAUS	8,542	56,021	778	65,341
SUTTER	2,117	13,270	186	15,574
TEHAMA	4,078	37,766	475	42,319
TRINITY	819	4,958	73	5,850
TULARE	14,186	140,332	1,727	156,245
TUOLUMNE	1,447	6,713	106	8,266
VENTURA	17,656	68,860	1,170	87,686
YOLO	5,665	49,131	627	55,423
YUBA	1,647	9,059	134	10,840

Table 3-17. TRUCK DVMT BY MOTIVE POWER FOR CALIFORNIA-BASED AND OUT-OF-STATE TRUCKS IN SELECTED COUNTIES
(All Values in 1,000's)

County/Base-Plate	Gasoline (%)	Diesel (%)	Other (%)	Total (%)
ALAMEDA				
California	530(43)	672(55)	18(1)	1,220*(100)
Out-of-State	32(14)	193(85)	3(1)	227*(100)
BUTTE				
California	96(50)	93(48)	3(2)	192*(100)
Out-of-State	5(17)	24(80)	N(2)	30*(100)
KERN				
California	442(29)	1,067(70)	20(1)	1,529*(100)
Out-of-State	34(9)	351(90)	4(1)	388*(100)
LOS ANGELES				
California	4,304(55)	3,396(43)	126(2)	7,826*(100)
Out-of-State	229(22)	809(77)	14(1)	1,052*(100)
SAN FRANCISCO				
California	168(60)	108(38)	5(2)	281*(100)
Out-of-State	9(29)	22(71)	N(1)	31*(100)
STATE TOTAL				
California	14,350(47)	15,916(52)	471(2)	30,737*(100)
Out-of-State	831(16)	4,389(83)	66(1)	5,286*(100)

Note: (1) N: Less than unity but not zero

(2) Due to round-off, the sum of elements may not equal the total

(3) The numeral with * is used to compute the percentages of elements to the total

Table 3-18. TRUCK DVMT BY MOTIVE POWER ON RURAL ROADS IN EACH COUNTY

RURAL ROADS

REGION	GASOLINE	DIESEL	OTHER	TOTAL
ALAMEDA	86,441	177,048	3,748	267,208
ALPINE	2,256	2,758	76	5,067
AMADOR	19,488	22,153	659	42,305
BUTTE	68,684	89,837	2,426	161,646
CALAVERAS	17,247	21,439	600	39,227
COLUSA	34,918	127,121	2,030	165,789
CONTRA COSTA	35,672	56,085	1,353	93,103
DEL NORTE	17,928	30,831	729	49,215
EL DORADO	53,623	62,621	1,793	117,975
FRESNO	221,261	533,649	10,145	764,868
GLENN	29,085	112,745	1,758	143,536
HUMBOLDT	68,334	119,157	2,917	190,931
IMPERIAL	91,559	203,213	3,979	299,137
INYO	41,752	61,901	1,532	105,022
KERN	372,951	1,241,334	20,500	1,634,291
KINGS	57,628	172,470	2,980	233,029
LAKE	27,951	25,448	866	54,225
LASSEN	50,091	66,423	1,844	118,222
LOS ANGELES	333,226	378,159	11,053	722,456
MADERA	58,270	190,614	3,139	251,924
MARIN	23,708	29,218	815	53,727
MARIPOSA	7,249	5,182	202	12,569
MENDOCINO	75,809	116,031	2,973	194,630
MERCED	106,960	359,531	5,997	472,388
MODOC	17,795	22,965	644	41,326
MONO	15,551	24,207	621	40,233
MONTEREY	141,228	232,307	5,463	378,859
NAPA	30,891	36,597	1,055	68,498
NEVADA	47,640	85,030	1,890	138,046
ORANGE	101,508	111,055	3,328	215,831
PLACER	88,260	172,981	3,748	266,692
PLUMAS	21,534	30,211	799	52,482
RIVERSIDE	430,064	815,270	17,476	1,262,850
SACRAMENTO	81,014	146,496	3,278	230,697
SAN BENITO	30,306	47,349	1,119	78,771
SAN BERNARDIN	391,872	842,300	17,498	1,251,244
SAN DIEGO	169,685	175,570	5,427	350,600
SAN FRANCISCO	0	0	0	0
SAN JOAQUIN	163,853	437,090	8,053	610,640
SAN LUIS OBIS	103,760	162,383	3,908	269,907
SAN MATEO	34,771	40,568	1,184	76,499
SANTA BARBARA	93,595	153,033	3,619	250,888
SANTA CLARA	62,638	111,509	2,545	176,668
SANTA CRUZ	42,848	52,836	1,484	97,118
SHASTA	102,731	212,485	4,533	319,682
SIERRA	8,393	18,477	398	27,267
SISKIYOU	93,189	264,936	5,118	363,138
SOLANO	68,616	170,933	3,297	242,748
SONOMA	100,077	155,696	3,816	259,476
STANISLAUS	93,049	190,145	3,977	287,109
SUTTER	27,048	49,755	1,086	77,849
TEHAMA	55,170	146,750	2,718	204,596
TRINITY	13,781	22,480	574	36,829
TULARE	165,643	501,578	8,556	675,466
TUOLUMNE	27,072	32,197	925	60,147
VENTURA	103,798	125,205	3,577	232,519
YOLO	59,917	158,844	2,908	221,608
YUBA	18,647	29,073	703	48,407

Table 3-19. TRUCK DVMT BY MOTIVE POWER ON URBAN ROADS IN EACH COUNTY

REGION	GASOLINE	DIESEL	OTHER	TOTAL
ALAMEDA	475,096	687,344	17,477	1,179,817
ALPINE	0	0	0	0
AMADOR	0	0	0	0
BUTTE	32,677	26,897	981	60,712
CALAVERAS	0	0	0	0
COLUSA	0	0	0	0
CONTRA COSTA	260,635	337,372	9,122	607,075
DEL NORTE	0	0	0	0
EL DORADO	15,048	11,862	443	27,343
FRESNO	146,831	184,075	5,006	335,864
GLENN	0	0	0	0
HUMBOLDT	19,388	23,975	700	44,154
IMPERIAL	11,671	15,799	407	27,901
INYO	0	0	0	0
KERN	102,183	176,194	3,966	282,286
KINGS	8,342	6,533	245	15,119
LAKE	0	0	0	0
LASSEN	2,203	1,997	70	4,266
LOS ANGELES	4,199,689	3,826,747	129,358	8,155,947
MADERA	5,934	12,387	250	18,565
MARIN	82,098	75,446	2,544	160,056
MARIPOSA	0	0	0	0
MENDOCINO	7,429	6,916	236	14,574
MERCED	15,649	29,734	641	46,016
MODOC	0	0	0	0
MONO	42	24	1	67
MONTEREY	65,964	68,642	2,126	136,701
NAPA	15,877	12,098	467	28,432
NEVADA	5,717	5,610	179	11,673
ORANGE	1,142,711	990,062	34,690	2,166,985
PLACER	32,445	39,497	1,113	73,357
PLUMAS	0	0	0	0
RIVERSIDE	264,176	349,172	9,188	622,551
SACRAMENTO	378,015	425,319	12,529	815,658
SAN BENITO	2,657	3,651	93	6,401
SAN BERNARDIN	309,287	433,909	11,258	754,275
SAN DIEGO	884,470	703,502	26,096	1,613,805
SAN FRANCISCO	176,786	130,444	5,160	312,375
SAN JOAQUIN	80,469	110,353	2,863	194,004
SAN LUIS OBIS	35,655	40,102	1,177	76,903
SAN MATEO	251,971	237,229	7,936	497,017
SANTA BARBARA	79,955	88,487	2,637	171,369
SANTA CLARA	623,748	724,509	21,106	1,369,248
SANTA CRUZ	49,193	40,951	1,484	91,600
SHASTA	30,980	46,162	1,166	78,295
SIERRA	0	0	0	0
SISKIYOU	3,202	8,099	164	11,461
SOLANO	79,688	129,709	3,082	212,416
SONOMA	59,899	61,942	1,940	123,741
STANISLAUS	53,826	56,319	1,734	111,866
SUTTER	10,076	9,117	308	19,496
TEHAMA	5,524	9,136	213	14,871
TRINITY	0	0	0	0
TULARE	41,905	70,028	1,597	113,492
TUOLUMNE	0	0	0	0
VENTURA	237,797	222,345	7,461	467,518
YOLO	27,945	45,854	1,066	74,850
YUBA	11,116	12,421	367	23,897

Table 3-20. TRUCK DVMT BY MOTIVE POWER ON RURAL, URBAN, AND ALL ROADS IN SELECTED COUNTIES
(All Values in 1,000's)

County/Road-Type	Gasoline	Diesel	Other	Total
ALAMEDA	562(39)	864(60)	21(1)	1,447*(100)
Rural	86(6)	177(12)	4(0)	267(18)
Urban	475(33)	687(47)	17(1)	1,180(82)
BUTTE	101(45)	117(53)	3(1)	222*(100)
Rural	69(31)	90(41)	2(1)	162(73)
Urban	33(15)	27(12)	1(0)	61(27)
KERN	475(25)	1,418(74)	24(1)	1,917*(100)
Rural	373(19)	1,241(65)	21(1)	1,634(85)
Urban	102(5)	176(9)	4(0)	282(15)
LOS ANGELES	4,533(51)	4,205(47)	140(2)	8,878*(100)
Rural	333(4)	378(4)	11(0)	722(8)
Urban	4,200(47)	3,827(43)	129(1)	8,156(92)
SAN FRANCISCO	177(57)	130(42)	5(2)	312*(100)
Rural	0	0	0	0
Urban	177(57)	130(42)	5(2)	312(100)
STATE TOTAL	15,181(42)	20,305(56)	537(1)	36,029*(100)
Rural	4,848(13)	9,824(27)	207(1)	14,886(41)
Urban	10,333(29)	10,480(29)	330(1)	21,143(59)

Note: (1) Due to round-off, the sum of elements may not equal the total

(2) The numeral with * is used to compute the percentages of elements to the total

4.0 VMT ESTIMATES FOR AIR BASINS

This chapter discusses truck VMT by various HDV subcategories in California's air basins. The estimation methodology described in Chapter 2.0 and Section 3.1 was applied to individual air basins instead of counties. Section 4.1 describes the county-to-air-basin conversion. Section 4.2 discusses estimated truck VMT by various HDV subcategories for air basins. Section 4.3 focuses on VMT by out-of-state trucks and California-based trucks.

4.1 COUNTY-TO-AIR BASIN CONVERSION

There are fourteen air basins and 58 counties in California. The geographical boundaries of these air basins and counties are depicted in Figure 4-1. Although most of the counties lie within individual air basins, a few are split between two different air basins. These split counties are: Los Angeles, Kern, Riverside, San Bernardino, Shasta, Solano and Sonoma.

In order to calculate truck VMT for an air basin from VMT of its member counties, both rural and urban portions of the county total VMT must be appropriately apportioned to their corresponding air basins. Table 4-1 lists the 14 air basins and their member counties. The table also indicates what fractions of county total VMT in rural and urban areas should be assigned to each air basin to which the county belongs. When a whole county lies within a single air basin, both the rural VMT fraction and the urban VMT fraction are set to unity (for example, Del Norte County in North Coast Air Basin).

When a county is split between two air basins, its rural VMT is apportioned to the two air basins according to the approximate proportions of the county's rural road miles falling in the two basins. These proportions are estimated by visually measuring the county's rural road miles of major highways in each of the two basins, using a street map. The county's urban VMT is apportioned to the two air basins according to the proportions of the county's population residing in the two basins. Based on the 1980 census population counts, ARB has developed a table showing the

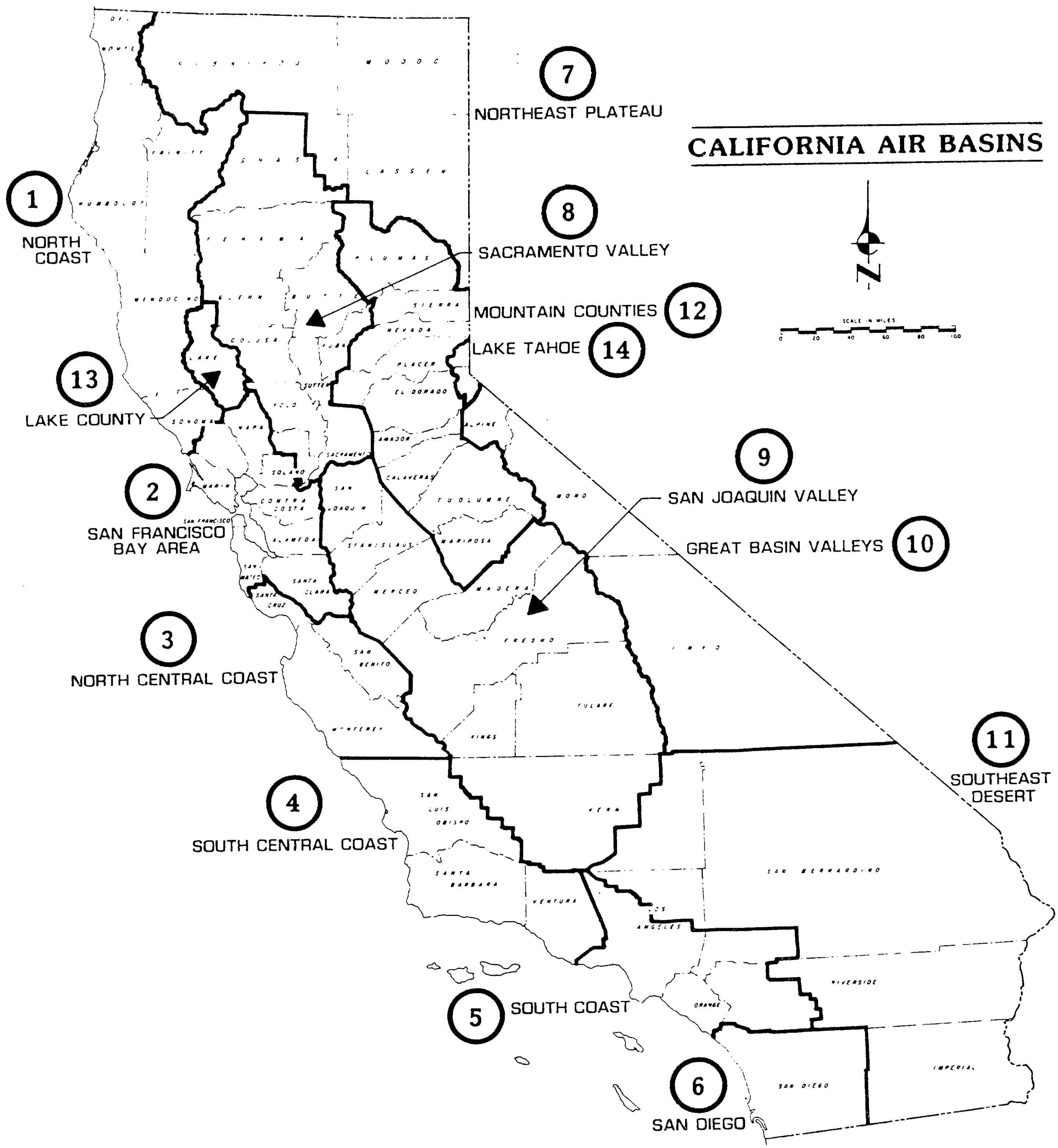


Figure 4-1. California's 14 Air Basins and 58 Counties

Table 4-1. CALIFORNIA AIR BASINS AND THEIR MEMBER COUNTIES

Air Basin	Member Counties	Rural VMT Fraction*	Urban VMT Fraction**
1. North Coast	Del Norte	1	1
	Humbolt	1	1
	Mendocino	1	1
	Sonoma	0.50	0.17
	Trinity	1	1
2. San Francisco B.A.	Alameda	1	1
	Contra Costa	1	1
	Marin	1	1
	Napa	1	1
	San Francisco	1	1
	San Mateo	1	1
	Santa Clara	1	1
	Solano	0.50	0.73
	Sonoma	0.50	0.83
3. North Central Coast	Monterey	1	1
	San Benito	1	1
	Santa Cruz	1	1
4. South Central Coast	San Luis Obispo	1	1
	Santa Barbara	1	1
	Ventura	1	1
5. South Coast	Los Angeles	0.60	0.99
	Orange	1	1
	Riverside	0.20	0.72
	San Bernardino	0.10	0.80
6. San Diego	San Diego	1	1
7. Northeast Plateau	Lassen	1	1
	Modoc	1	1
	Shasta	0.20	0.07
	Siskiyou	1	1
8. Sacramento Valley	Butte	1	1
	Colusa	1	1
	Glenn	1	1
	Sacramento	1	1
	Shasta	0.80	0.93
	Solano	0.50	0.37
	Sutter	1	1
	Tehama	1	1
	Yuba	1	1

Table 4-1. CALIFORNIA AIR BASINS AND THEIR MEMBER COUNTIES (CONTINUED)

Air Basin	Member Counties	Rural VMT Fraction*	Urban VMT Fraction**
9. San Joaquin Valley	Fresno	1	1
	Kern	0.70	0.86
	Kings	1	1
	Madera	1	1
	Merced	1	1
	San Joaquin	1	1
	Stanislaus	1	1
	Tulare	1	1
10. Great Basin Valley	Alpine	1	1
	Inyo	1	1
	Mono	1	1
11. Southeast Desert	Imperial	1	1
	Kern	0.30	0.14
	Los Angeles	0.40	0.01
	Riverside	0.80	0.28
	San Bernardino	0.90	0.20
12. Mountain Counties	Amador	1	1
	Calaveras	1	1
	El Dorado	0.90	0.70
	Mariposa	1	1
	Nevada	1	1
	Placer	0.95	0.93
	Plumas	1	1
	Sierra	1	1
	Tuolumne	1	1
13. Lake County	Lake	1	1
14. Lake Tahoe	El Dorado	0.10	0.30
	Placer	0.05	0.07

*Fraction of the county total VMT on rural roads, which belongs to the listed air basin--an estimate based on the county's rural road miles in that air basin as compared to those in the other air basin.

**Fraction of the county total VMT on urban roads, which belongs to the listed air basin--an estimate based on the county's resident population in that air basin as compared to that in the other air basin.

county total population or, in the case of split counties, the actual population residing in each air basin. The population counts listed were used to calculate, for each split county, the proportion of the urban truck VMT to be assigned to each of its two air basins.

Because, as described above, different principles are applied to the allocation of rural and urban truck VMT, the resulting proportions of the county's rural and urban VMT to that air basin are quite different. For example, Sonoma County partially belongs to the North Coast Air Basin and partially to the San Francisco Bay Area Air Basin. The rural VMT proportion assignable to the former air basin is 50% while the urban proportion is 17%. Conversely, the rural VMT proportion assignable to the latter air basin is 50% while the urban proportion is 83%.

4.2 TRUCK VMT BY SUB-CATEGORIES

For each of the fourteen air basins shown in Figure 4-1, annual average daily VMT (DVMT) by trucks and their various subcategories was computed by a program which was essentially the same as the one used in estimating truck VMT for counties. Table 4-2 presents truck VMT on state highways and on city and county roads in each air basin. The table also gives truck VMT in rural and urban portions of the air basin.

On a statewide basis, Table 4-2 shows that state highways carry 25 million vehicle miles per day, while city and county roads carry 11 million. Similarly, urban roads (i.e., all roads in urban areas) carry 21 million vehicle miles per day while rural roads carry 15 million. Therefore, it can be said that truck traffic takes place primarily on state highways (69%) rather than on city and county roads (31%), and in urban areas (59%) rather than in rural areas (41%). For the latter contrast, however, roads in rural areas carry more truck VMT by the heaviest class of trucks than do roads in urban areas. (This point is substantiated by DVMT values listed in Tables 4-3 and 4-4.)

Table 4-2 indicates that the South Coast Air Basin (A.B.) accounts for about a third of state total truck VMT on all roads, and slightly over a half on urban roads. As for truck VMT on rural roads, however, the South

Table 4-2. ANNUAL AVERAGE DAILY TRUCK VMT BY AIR BASIN
(State Highway vs. Non-State Roads, and Rural Roads vs. Urban Roads)

REGION	STATE ROADS	NON-STATE	TOTAL
NORTH COAST	537,799	165,864	703,663
S.F.BAY AREA	3,474,416	1,924,435	5,398,851
N.CEN. COAST	551,548	237,902	789,450
S.CEN. COAST	1,067,377	401,726	1,469,104
SOUTH COAST	7,658,952	4,629,567	12,288,520
SAN DIEGO AB	1,123,538	840,867	1,964,405
N.E. PLATEAU	530,346	77,406	607,753
SACTO.VALLEY	1,708,011	787,748	2,495,759
SAN JOAQ.VAL	4,351,678	1,165,442	5,517,120
GREAT BASIN	138,225	12,164	150,389
S.E.DESERT	3,126,533	593,934	3,720,467
MOUNTAIN AB.	614,838	215,776	830,613
LAKE CO.A.B.	41,390	12,835	54,225
LAKE TAHOE	25,834	12,636	38,470
CALIFORNIA	24,950,480	11,078,300	36,028,790
RURAL ROADS			
NORTH COAST	475,172	126,171	601,343
S.F.BAY AREA	804,037	182,778	986,815
N.CEN. COAST	439,505	115,243	554,748
S.CEN. COAST	643,492	109,822	753,313
SOUTH COAST	810,281	216,718	1,026,999
SAN DIEGO AB	265,749	84,851	350,600
N.E. PLATEAU	514,066	72,557	586,623
SACTO.VALLEY	1,150,474	259,164	1,409,638
SAN JOAQ.VAL	3,790,872	648,555	4,439,427
GREAT BASIN	138,225	12,097	150,323
S.E.DESERT	2,808,306	406,500	3,214,806
MOUNTAIN AB.	563,894	167,684	731,578
LAKE CO.A.B.	41,390	12,835	54,225
LAKE TAHOE	19,421	5,711	25,132
CALIFORNIA	12,464,880	2,420,686	14,885,570
URBAN ROADS			
NORTH COAST	62,627	39,693	102,320
S.F.BAY AREA	2,670,380	1,741,657	4,412,036
N.CEN. COAST	112,043	122,659	234,702
S.CEN. COAST	423,885	291,905	715,790
SOUTH COAST	6,848,671	4,412,849	11,261,520
SAN DIEGO AB	857,789	756,017	1,613,805
N.E. PLATEAU	16,280	4,850	21,130
SACTO.VALLEY	557,537	528,584	1,086,121
SAN JOAQ.VAL	560,806	516,886	1,077,692
GREAT BASIN	0	67	67
S.E.DESERT	318,227	187,433	505,661
MOUNTAIN AB.	50,944	48,092	99,035
LAKE CO.A.B.	0	0	0
LAKE TAHOE	6,414	6,924	13,338
CALIFORNIA	12,485,600	8,657,614	21,143,220

Coast A.B. is surpassed by the San Joaquin Valley A.B. and the South East Desert A.B. by large margins, and by the Sacramento Valley A.B. by a small margin. The San Francisco Bay Area A.B. is a distant second in truck VMT on urban roads. Several rural air basins (North Coast, North Central Coast, North East Plateau, Great Basin, Mountain, Lake County, Lake Tahoe) have each less than 1 million vehicle miles per day. The Lake Tahoe A.B. has the smallest VMT among the 14 air basins; it has no urban roads and thus no urban VMT.

Table 4-3 lists VMT by axle class for all roads, rural roads and urban roads. On a statewide basis, 2-axles accumulate the largest VMT (17 million), followed by 5+axles (14 million), 3-axles (4 million) and 4-axles (2 million). As for VMT by 2-axles, the South Coast A.B. has the largest VMT (7.0 million), followed by the San Francisco Bay Area A.B. (2.6 million) and the San Joaquin Valley A.B. (1.6 million). However, the South Coast A.B. is narrowly surpassed by the San Joaquin Valley A.B. on VMT by 5+axles (3.2 million vs. 3.3 million). On rural VMT, the San Joaquin Valley A.B. dominates: the first place in every axle class except for 4-axles. On urban VMT, the South Coast A.B. outdistances other counties in all four axle classes.

Table 4-4 presents truck VMT by weight class. On a statewide basis, heavy HDV s accumulate the most VMT (16 million), followed by medium HDV s (13 million) and light HDV s (7 million). Among the 14 air basins, the South Coast A.B. has the largest VMT in all three weight classes. The other extreme is the Lake Tahoe A.B., which has the smallest VMT in all three weight classes. As for rural VMT, however, the San Joaquin Valley A.B. dominates in all three weight classes, surpassing the South Coast and all other air basins. The Southeast Desert A.B. ranks second in rural VMT. As for urban VMT, the South Coast A.B. is, by far, the leader, accounting for nearly 50% or more than 50% of state total VMT in all classes.

Table 4-5 presents truck VMT by fuel type. On a statewide basis, diesel-powered trucks accumulate the most VMT (20 million), closely followed by gasoline-powered trucks (15 million). Trucks powered by other types of fuel travel, statewide, only half a million vehicle miles per day. The South Coast A.B. accounts for approximately 40% of state total VMT by

Table 4-3. TRUCK DVMT BY AXLE CLASS AND BY AIR BASIN

REGION	2-AXLES	3-AXLES	4-AXLES	5+AXLES
NORTH COAST	264,821	125,182	25,497	288,092
S.F.BAY AREA	2,566,307	712,250	194,342	1,926,722
N.CEN. COAST	364,075	92,672	31,450	301,504
S.CEN. COAST	720,472	181,462	71,522	495,038
SOUTH COAST	6,988,495	1,512,347	544,034	3,244,183
SAN DIEGO AB	1,217,085	246,515	77,640	423,509
N.E. PLATEAU	167,503	102,698	33,274	304,617
SACTO.VALLEY	985,703	281,769	92,241	1,134,072
SAN JOAQ.VAL	1,610,940	425,330	204,751	3,275,450
GREAT BASIN	63,194	16,061	13,196	58,270
S.E.DESERT	1,316,005	343,427	195,852	1,865,302
MOUNTAIN AB.	349,521	104,969	26,821	344,040
LAKE CO.A.B.	31,665	7,172	2,610	12,818
LAKE TAHOE	18,176	4,865	1,165	14,167
CALIFORNIA	16,663,960	4,156,721	1,514,397	13,687,780
RURAL ROADS				
NORTH COAST	219,278	108,192	22,355	251,515
S.F.BAY AREA	372,047	122,426	38,307	454,282
N.CEN. COAST	230,629	61,296	24,118	238,897
S.CEN. COAST	323,853	86,360	39,705	302,961
SOUTH COAST	468,612	109,392	53,959	395,121
SAN DIEGO AB	192,901	39,711	16,655	101,414
N.E. PLATEAU	160,242	99,209	32,261	295,243
SACTO.VALLEY	434,694	142,558	57,135	773,179
SAN JOAQ.VAL	1,121,367	314,039	169,992	2,833,539
GREAT BASIN	63,145	16,051	13,195	58,264
S.E.DESERT	1,071,340	287,186	173,629	1,682,759
MOUNTAIN AB.	297,664	91,854	24,015	313,223
LAKE CO.A.B.	31,665	7,172	2,610	12,818
LAKE TAHOE	10,458	3,056	827	10,711
CALIFORNIA	4,997,895	1,488,503	668,763	7,723,925
URBAN ROADS				
NORTH COAST	45,544	16,991	3,143	36,578
S.F.BAY AREA	2,194,260	589,823	156,035	1,472,441
N.CEN. COAST	133,445	31,376	7,332	62,608
S.CEN. COAST	396,619	95,102	31,817	192,077
SOUTH COAST	6,519,883	1,402,956	490,075	2,849,062
SAN DIEGO AB	1,024,184	206,804	60,985	322,095
N.E. PLATEAU	7,261	3,489	1,013	9,374
SACTO.VALLEY	551,009	139,211	35,106	360,892
SAN JOAQ.VAL	489,573	111,291	34,759	441,911
GREAT BASIN	49	10	1	6
S.E.DESERT	244,665	56,241	22,223	182,543
MOUNTAIN AB.	51,857	13,115	2,806	30,817
LAKE CO.A.B.	0	0	0	0
LAKE TAHOE	7,718	1,809	338	3,455
CALIFORNIA	11,666,070	2,668,218	845,633	5,963,859

Table 4-4. TRUCK DVMT BY WEIGHT CLASS AND BY AIR BASIN

REGION	LIGHT	MEDIUM	HEAVY	TOTAL
NORTH COAST	119,169	241,693	342,730	703,663
S.F.BAY AREA	1,154,838	1,974,176	2,270,607	5,398,851
N.CEN. COAST	163,834	275,490	350,378	789,450
S.CEN. COAST	324,212	546,886	597,396	1,469,104
SOUTH COAST	3,144,823	5,081,847	4,062,390	12,288,520
SAN DIEGO AB	547,688	867,579	549,482	1,964,405
N.E. PLATEAU	75,376	174,995	357,720	607,753
SACTO.VALLEY	443,566	769,815	1,280,404	2,495,759
SAN JOAQ.VAL	724,923	1,251,316	3,540,232	5,517,120
GREAT BASIN	28,437	50,354	71,930	150,389
S.E.DESERT	592,202	1,028,833	2,099,551	3,720,467
MOUNTAIN AB.	157,284	274,566	393,501	830,613
LAKE CO.A.B.	14,249	23,298	16,719	54,225
LAKE TAHOE	8,179	13,787	16,407	38,470
CALIFORNIA	7,498,782	12,574,630	15,949,450	36,028,790

RURAL ROADS

NORTH COAST	98,675	203,714	298,950	601,343
S.F.BAY AREA	167,421	302,966	516,676	986,815
N.CEN. COAST	103,783	177,712	273,445	554,748
S.CEN. COAST	145,734	251,674	355,471	753,313
SOUTH COAST	210,875	352,117	464,091	1,026,999
SAN DIEGO AB	86,806	139,390	124,486	350,600
N.E. PLATEAU	72,109	168,225	346,621	586,623
SACTO.VALLEY	195,612	357,727	854,227	1,409,638
SAN JOAQ.VAL	504,615	892,677	3,041,645	4,439,427
GREAT BASIN	28,415	50,319	71,920	150,323
S.E.DESERT	482,103	847,565	1,885,246	3,214,806
MOUNTAIN AB.	133,949	235,938	356,870	731,578
LAKE CO.A.B.	14,249	23,298	16,719	54,225
LAKE TAHOE	4,706	8,165	12,182	25,132
CALIFORNIA	2,249,053	4,011,486	8,618,548	14,885,570

URBAN ROADS

NORTH COAST	20,495	37,980	43,781	102,320
S.F.BAY AREA	987,417	1,671,211	1,753,931	4,412,036
N.CEN. COAST	60,050	97,778	76,933	234,702
S.CEN. COAST	178,479	295,212	241,925	715,790
SOUTH COAST	2,933,947	4,729,730	3,598,299	11,261,520
SAN DIEGO AB	460,883	728,189	424,996	1,613,805
N.E. PLATEAU	3,267	6,770	11,100	21,130
SACTO.VALLEY	247,954	412,088	426,176	1,086,121
SAN JOAQ.VAL	220,308	358,639	498,587	1,077,692
GREAT BASIN	22	35	10	67
S.E.DESERT	110,099	181,269	214,305	505,661
MOUNTAIN AB.	23,335	38,628	36,632	99,035
LAKE CO.A.B.	0	0	0	0
LAKE TAHOE	3,473	5,622	4,224	13,338
CALIFORNIA	5,249,730	8,563,149	7,330,898	21,143,220

Table 4-5. TRUCK DVMT BY FUEL TYPE AND BY AIR BASIN

REGION	GASOLINE	DIESEL	OTHER	TOTAL
NORTH COAST	269,519	423,396	10,678	703,663
S.F.BAY AREA	2,352,684	2,965,005	81,931	5,398,851
N.CEN. COAST	332,196	445,736	11,768	789,450
S.CEN. COAST	654,560	791,554	22,381	1,469,104
SOUTH COAST	6,148,367	5,947,613	193,079	12,288,520
SAN DIEGO AB	1,054,155	879,073	31,522	1,964,405
N.E. PLATEAU	189,164	410,101	8,827	607,753
SACTO.VALLEY	926,795	1,531,092	35,898	2,495,759
SAN JOAQ.VAL	1,568,563	3,874,967	72,942	5,517,120
GREAT BASIN	59,602	88,890	2,230	150,389
S.E.DESERT	1,253,586	2,415,140	51,861	3,720,467
MOUNTAIN AB.	327,154	486,025	12,172	830,613
LAKE CO.A.B.	27,951	25,448	866	54,225
LAKE TAHOE	16,561	21,234	578	38,470
CALIFORNIA	15,180,850	20,305,270	536,733	36,028,790

RURAL ROADS

NORTH COAST	225,890	366,347	9,101	601,343
S.F.BAY AREA	358,467	614,340	14,256	986,815
N.CEN. COAST	214,382	332,492	8,066	554,748
S.CEN. COAST	301,153	440,620	11,105	753,313
SOUTH COAST	426,644	585,234	15,204	1,026,999
SAN DIEGO AB	169,685	175,570	5,427	350,600
N.E. PLATEAU	181,621	396,821	8,513	586,623
SACTO.VALLEY	431,060	957,233	19,274	1,409,638
SAN JOAQ.VAL	1,127,730	3,254,011	57,197	4,439,427
GREAT BASIN	59,560	88,866	2,229	150,323
S.E.DESERT	1,033,471	2,137,164	44,279	3,214,806
MOUNTAIN AB.	280,730	435,380	10,647	731,578
LAKE CO.A.B.	27,951	25,448	866	54,225
LAKE TAHOE	9,775	14,911	367	25,132
CALIFORNIA	4,848,119	9,824,438	206,530	14,885,570

URBAN ROADS

NORTH COAST	43,629	57,049	1,577	102,320
S.F.BAY AREA	1,994,218	2,350,665	67,676	4,412,036
N.CEN. COAST	117,814	113,244	3,703	234,702
S.CEN. COAST	353,407	350,934	11,276	715,790
SOUTH COAST	5,721,723	5,362,379	177,875	11,261,520
SAN DIEGO AB	884,470	703,502	26,096	1,613,805
N.E. PLATEAU	7,542	13,281	314	21,130
SACTO.VALLEY	495,735	573,859	16,624	1,086,121
SAN JOAQ.VAL	440,833	620,956	15,745	1,077,692
GREAT BASIN	42	24	1	67
S.E.DESERT	220,115	277,977	7,581	505,661
MOUNTAIN AB.	46,424	50,645	1,525	99,035
LAKE CO.A.B.	0	0	0	0
LAKE TAHOE	6,785	6,323	211	13,338
CALIFORNIA	10,332,740	10,480,840	330,203	21,143,220

gasoline-powered trucks and 30% of state total VMT by diesel-powered trucks. On rural roads, diesel-powered trucks dominate over gasoline-powered trucks by 2 to 1 ratio. The San Joaquin Valley A.B. has the largest rural VMT among the 14 air basins, particularly that by diesel-powered trucks. On urban roads, gasoline-powered trucks accumulate as much VMT as do diesel-powered trucks. The South Coast A.B. has, by far, the largest urban VMT, accounting for over 50% of state total VMT in both gasoline- and diesel-powered trucks.

4.3 TRUCK VMT BY OUT-OF-STATE TRUCKS

Estimates of truck VMT by out-of-state vehicles and California-based vehicles are tabulated for each of the 14 air basins and for rural and urban roads, separately, in Table 4-6. On a statewide basis, out-of-state trucks travel 5.3 million vehicle miles per day or about 15% of state total truck VMT. These out-of-state trucks travel equally on rural and urban roads, each with 2.6 million vehicles miles per day. As to out-of-state truck content in the traffic, rural roads carry a higher proportion (18%) than do urban roads (13%).

Among the 14 air basins, the South Coast A.B. is ranked first both in VMT by out-of-state trucks and in VMT by California-based trucks. The second place in VMT by California-based trucks falls to the San Francisco Bay Area A.B. while that in VMT by out-of-state trucks falls to the San Joaquin Valley A.B. As a result, the proportion of out-of-state trucks in basin total truck VMT is the highest in the San Joaquin Valley A.B. (19%), followed by the San Francisco Bay Area A.B. (15%) and the South Coast A.B. (12%). Such an order in out-of-state truck content among the three air basins is not surprising. The San Joaquin Valley A.B. contains several major trucking routes and has a high proportion of rural roads, both of which are characterized by a high out-of-state truck content. On the other hand, the South Coast A.B. has a high proportion of urban roads, which are characterized by a low out-of-state truck content.

Table 4-7 presents VMT by weight class for out-of-state trucks and California-based trucks. It should be noted that while California-based truck VMT is about evenly distributed over the three weight classes, out-

Table 4-6. TRUCK DVMT ON RURAL AND URBAN ROADS FOR OUT-OF-STATE TRUCKS VS. CALIFORNIA-BASED TRUCKS

*** DVMT FOR OUT-OF-STATE VEHICLES ***

REGION	RURAL	URBAN	TOTAL
NORTH COAST	95,899	14,714	110,614
S.F.BAY AREA	162,703	603,456	766,160
N.CEN. COAST	87,606	28,440	116,046
S.CEN. COAST	115,450	88,387	203,837
SOUTH COAST	152,758	1,343,343	1,496,101
SAN DIEGO AB	44,579	172,267	216,846
N.E. PLATEAU	105,844	3,501	109,346
SACTO.VALLEY	257,973	147,232	405,205
SAN JOAQ.VAL	889,943	162,746	1,052,689
GREAT BASIN	23,290	5	23,295
S.E.DESERT	574,333	72,041	646,375
MOUNTAIN AB.	114,530	12,908	127,438
LAKE CO.A.B.	6,339	0	6,339
LAKE TAHOE	3,920	1,582	5,502
CALIFORNIA	2,635,169	2,650,624	5,285,792

*** TRUCK DVMT FOR CALIFORNIA VEHICLES ***

REGION	RURAL	URBAN	TOTAL
NORTH COAST	505,439	87,540	592,979
S.F.BAY AREA	824,359	3,809,102	4,633,461
N.CEN. COAST	467,334	206,321	673,655
S.CEN. COAST	637,429	627,229	1,264,658
SOUTH COAST	874,325	9,918,634	10,792,960
SAN DIEGO AB	306,103	1,441,801	1,747,904
N.E. PLATEAU	481,110	17,636	498,746
SACTO.VALLEY	1,149,593	938,987	2,088,580
SAN JOAQ.VAL	3,548,994	914,788	4,463,782
GREAT BASIN	127,364	61	127,426
S.E.DESERT	2,640,580	433,632	3,074,212
MOUNTAIN AB.	612,227	85,686	697,914
LAKE CO.A.B.	47,926	0	47,926
LAKE TAHOE	21,133	11,737	32,870
CALIFORNIA	12,243,920	18,493,150	30,737,080

Table 4-7. TRUCK DVMT BY WEIGHT CLASS FOR OUT-OF-STATE TRUCKS VS. CALIFORNIA-BASED TRUCKS

*** DVMT FOR CALIFORNIA VEHICLES ***

REGION	LIGHT	MEDIUM	HEAVY	TOTAL
NORTH COAST	115,594	227,192	250,193	592,979
S.F.BAY AREA	1,120,193	1,855,726	1,657,543	4,633,461
N.CEN. COAST	158,919	258,960	255,776	673,655
S.CEN. COAST	314,486	514,072	436,099	1,264,658
SOUTH COAST	3,050,478	4,776,936	2,965,545	10,792,960
SAN DIEGO AB	531,258	815,524	401,122	1,747,904
N.E. PLATEAU	73,115	164,496	261,136	498,746
SACTO.VALLEY	430,259	723,626	934,695	2,088,580
SAN JOAQ.VAL	703,175	1,176,237	2,584,369	4,463,782
GREAT BASIN	27,584	47,333	52,509	127,426
S.E.DESERT	574,436	967,103	1,532,672	3,074,212
MOUNTAIN AB.	152,566	258,092	287,256	697,914
LAKE CO.A.B.	13,822	21,900	12,205	47,926
LAKE TAHOE	7,934	12,960	11,977	32,870
CALIFORNIA	7,273,819	11,820,160	11,643,100	30,737,070

*** DVMT FOR NON-CALIFORNIA VEHICLES ***

REGION	LIGHT	MEDIUM	HEAVY	TOTAL
NORTH COAST	3,575	14,502	92,537	110,614
S.F.BAY AREA	34,645	118,451	613,064	766,160
N.CEN. COAST	4,915	16,529	94,602	116,046
S.CEN. COAST	9,726	32,813	161,297	203,837
SOUTH COAST	94,345	304,911	1,096,845	1,496,101
SAN DIEGO AB	16,431	52,055	148,360	216,846
N.E. PLATEAU	2,261	10,500	96,584	109,345
SACTO.VALLEY	13,307	46,189	345,709	405,205
SAN JOAQ.VAL	21,748	75,079	955,863	1,052,689
GREAT BASIN	853	3,021	19,421	23,295
S.E.DESERT	17,766	61,730	566,879	646,375
MOUNTAIN AB.	4,719	16,474	106,245	127,438
LAKE CO.A.B.	427	1,398	4,514	6,339
LAKE TAHOE	245	827	4,430	5,502
CALIFORNIA	224,963	754,478	4,306,351	5,285,792

of-state truck VMT is almost entirely generated by heavy HDV s (81%). This is understandable because, being engaged in interstate commerce, heavy HDV s would be preferred to lighter HDV s by out-of-state truckers. Particularly in the San Joaquin Valley A.B., heavy HDV s account for over 90% of the basin total VMT by out-of-state trucks.

Table 4-8 presents VMT by fuel type (i.e., motive power) for out-of-state trucks and California-based trucks. On a statewide basis, among out-of-state vehicles, diesel-powered trucks overwhelmingly outnumber gasoline-powered trucks (4.4 million vs. 0.8 million), but among California-based trucks the numbers are more nearly equal (16 million vs. 14 million). Trucks powered by other types of fuel account for only about 1% of total VMT both among out-of-state trucks and California-based trucks.

As for VMT by diesel-powered out-of-state trucks, the San Joaquin Valley A.B. is a close second behind the South Coast A.B. but as for VMT by gasoline-powered trucks, the same air basin takes a distant third place after the South Coast A.B. and the San Francisco Bay Area A.B. The rankings are the same for California-based trucks, as well. As in the case of heavy HDV s, out-of-state truckers seem to prefer diesel-powered trucks to gasoline-powered trucks.

Table 4-8. TRUCK DVMT BY FUEL TYPE FOR OUT-OF-STATE VS. CALIFORNIA-BASED TRUCKS

*** TRUCK DVMT BY FUEL TYPE FOR NON-CALIF. VEHICLES ***

REGION	GASOLINE	DIESEL	OTHER	TOTAL
NORTH COAST	15,654	93,600	1,360	110,614
S.F.BAY AREA	127,321	629,154	9,684	766,160
N.CEN. COAST	18,206	96,399	1,442	116,046
S.CEN. COAST	35,052	166,187	2,597	203,837
SOUTH COAST	313,399	1,162,586	20,116	1,496,101
SAN DIEGO AB	52,256	161,545	3,045	216,846
N.E. PLATEAU	12,206	95,858	1,281	109,345
SACTO.VALLEY	53,721	346,641	4,843	405,205
SAN JOAQ.VAL	103,191	937,687	11,811	1,052,689
GREAT BASIN	3,370	19,641	285	23,295
S.E.DESERT	75,974	562,881	7,521	646,375
MOUNTAIN AB.	18,452	107,429	1,557	127,438
LAKE CO.A.B.	1,411	4,841	87	6,339
LAKE TAHOE	898	4,535	69	5,502
CALIFORNIA	831,111	4,388,983	65,698	5,285,792

*** TRUCK DVMT BY FUEL TYPE FOR CALIFORNIA VEHICLES ***

REGION	GASOLINE	DIESEL	OTHER	TOTAL
NORTH COAST	253,866	329,796	9,318	592,979
S.F.BAY AREA	2,225,363	2,335,851	72,247	4,633,461
N.CEN. COAST	313,990	349,338	10,327	673,655
S.CEN. COAST	619,509	625,366	19,783	1,264,658
SOUTH COAST	5,834,968	4,785,027	172,964	10,792,960
SAN DIEGO AB	1,001,899	717,528	28,477	1,747,904
N.E. PLATEAU	176,957	314,243	7,546	498,746
SACTO.VALLEY	873,073	1,184,451	31,056	2,088,580
SAN JOAQ.VAL	1,465,371	2,937,280	61,131	4,463,782
GREAT BASIN	56,232	69,249	1,945	127,426
S.E.DESERT	1,177,612	1,852,260	44,340	3,074,212
MOUNTAIN AB.	308,702	378,596	10,615	697,914
LAKE CO.A.B.	26,540	20,607	779	47,926
LAKE TAHOE	15,662	16,699	509	32,870
CALIFORNIA	14,349,740	15,916,290	471,036	30,737,070

5.0 TRUCK POPULATION AND USAGE PATTERN

This section discusses the truck population in California and the usage patterns of trucks in each of the three HDV weight classes: light, medium and heavy. Since the ARB's HDV classes are different from the DMV's and also from the FHwA's, it is not a straightforward task to estimate the HDV population. Section 5.1 discusses the size and make-up of the HDV population in California. Section 5.2 describes the truck usage patterns which have been derived from results of the PES telephone questionnaire survey of fleet operators.

5.1 TRUCK POPULATION IN CALIFORNIA

The Department of Motor Vehicles uses "unladen weight" as a basis of the vehicle weight fee system. In this, the DMV differs from many other states, which use "gross vehicle weight" for such systems. Since there is no general relationship between unladen weight and GVW for individual trucks, it is rather difficult to convert the DMV's unladen-weight statistics to a GVW basis. The ARB defines HDVs as vehicles whose gross vehicle weight is over 8,500 pounds. This threshold value falls within the weight range of FHwA's Class II vehicles (6000 lbs $<$ GVW $\leq$ 10,000 lbs).

Recently, a CALTRANS contractor has conducted a very comprehensive study on the California vehicle population and VMT (Sydec 1984). Table 5-1 presents results of one of their studies, showing the estimated number of vehicles in each vehicle class for 1983. CALTRANS uses a (visual) criterion, two axles and six tires, as a basis to distinguish trucks from other vehicles. The same criterion was used in the PES Special Truck Traffic Survey and has proved to be a reasonable means of visually distinguishing HDVs from other vehicles.

Table 5-1 provides the estimated number of vehicles in each of the seven groups for California-based vehicles and also for out-of-state vehicles, which operate in California but are registered in other states. Although the estimates given in the table were derived from the DMV vehicle registration data, these estimates are particularly appropriate for the present study: The Pickups and Vans category has been redefined to exclude

Table 5-1. ESTIMATED NUMBER OF VEHICLES IN CALIFORNIA BY VEHICLE TYPE IN 1983 (after Sydec 1984; all values in 1,000's)

Vehicle Type	California-Based Vehicles	Out-of-State Vehicles	Total Vehicles
1. Automobiles	12,696	0	12,696
2. Motorcycles	632	0	632
3. Pickups and Vans	2,877	0	2,877
4. Recreational Vehicles	423	0	423
5. Buses	46	7	53
6. Single Unit Trucks	429	3	432
7. Combination Trucks	96	162	258
All Vehicles	17,199	172	17,371
Types 3 through 7	3,871	172	4,044
Types 5 through 7	571	172	743

[a] Apportioned-license vehicles which operate in California but are based in other states, i.e., "prorate" and "IRP" states.

[b] The Pickups and Vans category has been redefined to exclude all two-axle, six-tire vehicles, and the Single Unit Two-Axle Truck category has been redefined to exclude all four-tire vehicles, in order to achieve compatibility with the definitions which have been used in the CALTRANS traffic counting program.

[c] Recreational vehicles have been pulled out of the pickup and van category and treated as a separate class.

all two-axle, six-tire vehicles, and the Single Unit Two-Axle Truck category has been redefined to exclude all four-tired vehicles; and the number of California-based vehicles and that of out-of-state vehicles operating in California are separately estimated.

The last three rows of Table 5-1 show the size of the vehicle population and its subpopulations for 1983: The total vehicle population is 17.2 million; the truck population including pickups and vans is 3.9 million; and the large truck population, which seems to reasonably approximate the HDV population, is 571,000. These numbers are for California-based vehicles only. In addition, 172,000 out-of-state vehicles (all of them are large trucks) operate at least partially in California.

This last number is, at the best, a rough estimate, because it is based only on "prorate" vehicles based in other states and "IRP transactions" received from other IRP states. The estimate does not include any trucks entering California with temporary permits nor those trucks from "interstate reciprocity" states (16 states plus the District of Columbia and 6 Canadian provinces). Furthermore, the number of "IRP transactions" may not necessarily correspond to the number of other-IRP-state trucks which operator in California. Despite of all these flaws, the number of out-of-state trucks given in Table 5-1 is a good estimate and the only estimate which is now available.

Table 5-2 presents a similar estimate of the California-based truck population, which was made by a contractor to the California Energy Commission (CEC). Unlike the CALTRANS estimate, this CEC estimate is based on the truck GVW data which were provided by R.L. Polk and Company. The table shows that the numbers of trucks in Weight Class I ($0 < GVW \leq 6{,}000$ lbs) and Class II ($6{,}000 < GVW \leq 10{,}000$) are 2 million and 1 million while the total number of trucks in Class III ($10{,}000 < GVW \leq 14{,}000$ lbs) through Class VIII (over 33,000 lbs), including combination trucks, is only 0.3 million.

Table 5-2 also provides estimates of the numbers of HDVs by weight class, which PES has derived from the CEC estimate. Assuming that a fifth of all Class II trucks qualify as HDVs, the total number of HDVs in

Table 5-2. ESTIMATED NUMBER OF TRUCKS IN CALIFORNIA IN EACH WEIGHT CLASS IN 1977 (after JFA 1983; all values in 1000's)

FHwA Standard Weight Class (GVW in lbs)	Number	ARB's HDV Weight Class (GVW in lbs)	Number (%)
1. I (0-6)	1,913[a]		
2. II (6-10)	975[a]	Light (8.5-14)	217[b](46)
3. III,IV,V (10-19.5)	65		
4. VI (19.5-26)	91	Medium (14-33)	143 (30)
5. VII (26-33)	9		
6. VIII (over 33)	23	Heavy (over 33)	116 (24)
7. Combination trucks	93		
Classes 1 through 7	3,169		
Classes 2 through 7	1,256		
HDVs			476 (100)
Classes 3 through 7	281		

[a]Mostly pickups, vans and recreational vehicles
[b]Estimated as (1/5 of Class II + 1/3 of Classes III, IV and V)

California is estimated to be 476,000 in 1977, the base year used in the CEC study. This number is in fairly good agreement with the number of large trucks (571,000) calculated from the CALTRANS estimate, particularly when the population growth during the six year period (1977-1983) is taken into consideration.

The proportions of light, medium and heavy HDVs to the 1977 HDV population are 46%, 30% and 24%, respectively. By applying these proportions to the 1983 large truck population, the numbers of light, medium and heavy HDV s in California for 1983 are estimated to be 263,000, 171,000, and 137,000, respectively. In addition to these California-based HDVs, there are 172,000 out-of-state trucks, which are all considered to be heavy HDVs.

5.2 TRUCK USAGE PATTERN IN CALIFORNIA

PES has conducted a telephone questionnaire survey on the usage of HDVs by interviewing a representative sample of 233 fleet owners in California. The survey yielded information on the vehicle usage, as well as other pertinent information, for 622 HDVs. The method used and the results of the survey are described in subsections that follow.

5.2.1 DESIGN AND EXECUTION OF THE SURVEY

It was estimated that a total of 400 HDVs must be surveyed in order to obtain a statistically significant result. To maximize the accuracy of any estimate of the overall HDV activity level, the number of samples assigned to each of the three HDV weight classes was proportioned to an estimated relative contribution of HDVs in that weight class to the statewide VMT by all HDVs. Table 5-3 presents the target number of samples allocated to each weight class, the number of HDVs surveyed, and the *a priori* and *a posteriori* VMT values for HDVs in each weight class. A main reason for the difference between the *a priori* and *a posteriori* VMT values is that the former is given for truck VMT on state highways only, while the latter is given for truck VMT on all roads, including city and county roads as well.

The number of HDVs actually surveyed exceeded the target number by about 50% because many of the fleet owners surveyed provided the usage

Table 5-3. SUMMARY OF HDV USAGE SURVEY

Item	HDV Weight Class			
	Light	Medium	Heavy	Total
Target Number of HDVs	52 (13%)	88 (22%)	260 (65%)	400 (100%)
Number of HDVs Surveyed	77 (12%)	226 (36%)	319 (51%)	622 (100%)
A Priori VMT Distribution[a] (million miles/day)	2.7 (13%)	4.9 (22%)	14.0 (65%)	21.6 (100%)
A Posteriori VMT Distribution[b] (million miles/day)	7.5 (21%)	12.6 (35%)	15.9 (44%)	36.0 (100%)

[a]The estimates were based on VMT values provided by CEC (JFA 1983) and CALTRANS (1983)

[b]The estimates come from a result of the present study.

information for more than one HDV. (The questionnaire was designed to survey up to five HDVs at each fleet facility; see Appendix D). Although the distribution of HDVs actually surveyed over the three weight classes deviated from the target mix of HDVs, it turned out to be in fairly good agreement with the VMT distribution obtained from the present study (Table 5-3).

The source list of 3,500 randomly selected fleet owners was obtained from R.L. Polk and Company. Since the list included non-HDV owners for Class II vehicles, most of these owners were screened out by subjective judgment based on, the body-types of their vehicles (e.g., pickup, pickup camper, station wagon, etc.). This screening reduced the number to 2,101. Next, their telephone numbers were identified from the addresses by using telephone directories throughout the state. PES identified the telephone numbers for 1,331 fleet owners (63% of 2,101). These 1,331 fleet owners were grouped into the three HDV weight classes and their telephone numbers were randomized within each class prior to being given to telephone interviewers.

The progress of the telephone interviewing was periodically checked to achieve the target numbers of HDVs at a minimum cost. Oversight of the extent of multiple answers for HDVs at a same fleet facility resulted in about 50% over survey as mentioned earlier. The performance of the telephone interviews was quite good: Of the 449 attempted interviews, 233 (52%) were successful; of the 216 unsuccessful attempts, 115 were caused by: wrong or disconnected telephone numbers (65); no responses (47); and no English-speaking persons (3); 75 answered no HDV at their facilities; and 26 refused the interview.

5.2.2 RESULTS OF THE QUESTIONNAIRE SURVEY

All completed questionnaires were reviewed by PES technical staff to ensure that their answers to the questionnaire items were reasonable and internally consistent. There were a few cases in which the answers to some questions seemed to be unreasonable or inconsistent with the answers to related questions. For such cases, the staff called the respondent to clarify his responses to the particular questionnaire items.

In analyzing the questionnaire survey data, PES has noticed that the HDV weight class determined from the questionnaire response does not always agree with the Polk-provided GVW value. Such disagreement might conceivably be correct for questionnaire responses from multiple-HDV owners, but not for responses from single-HDV owners. Many disagreements occurred on responses from single-HDV owners as well as on responses from multiple-HDV owners.

Table 5-4 shows how well the survey-determined weight classes and the Polk-provided weight classes agree. Of the 542 cases for which their HDV classes were determined from the survey results, the survey-determined weight classes and the Polk-provided weight classes agreed in 371 cases (68.5%) and disagreed in 171 cases (31.5%). It is apparent in the table that the agreement rate is highest in the heavy HDV class, which is characterized by multiple-HDV owners, and lowest in the light HDV class, which is characterized by single-HDV owners.

Since the 371 matched pairs seem to be the most reliable subset of the survey data, the descriptive statistics of each questionnaire parameter are computed for the matched pairs only. Table 5-5 presents summary statistics of the usage parameters investigated in the survey. The mean and the sample size of each parameter are given for each weight class and separately for gasoline- and diesel-powered HDVs in the total sample. Since there were only two HDVs powered by other types of fuel in the entire set of matched pairs, survey data on these vehicles were excluded from the statistics given in Table 5-5.

The annual mileage accumulation rate is 13,000 for light HDVs and 23,000 for medium HDVs but that for heavy HDVs is 76,600. A similar difference in the annual mileage accumulation rates is seen between gasoline-powered HDVs (22,000) and diesel-powered HDVs (70,600). These values are in reasonable agreements with the estimates made by CALTRANS (1985) and the U.S. Department of Commerce (1979), which are presented in Table 5-6.

Table 5-4. NUMBER OF CASES OF AGREEMENT AND DISAGREEMENT IN WEIGHT CLASS BETWEEN THE SURVEY DATA AND THE POLK-PROVIDED DATA

Polk-Provided Weight Class	Survey-Determined Weight Class Non HDV	Light	Medium	Heavy	Total
Light	20	<u>31</u>	10	0	61
Medium	7	31	<u>93</u>	50	181
Heavy	2	2	49	<u>247</u>	300
Total	29	64	152	297	542

Notes: (1) There were 80 cases of incomplete data so that their HDV weight classes could not be determined from the survey data.

(2) The numerals underlined indicate the number of cases of agreement (matched pairs).

(3) The overall percentage of agreement between the survey-determined weight classes and the Polk-provided weight classes is 68.5% (=371/542).

Table 5-5. VEHICLE USAGE BY WEIGHT CLASS AND BY MOTIVE POWER

Usage Parameter	Mean Sample Size	Light HDV	Medium HDV	Heavy HDV	Total Gasoline	Total Diesel
Annual Mileage (1,000 miles)	m	13.0	23.0	76.6	22.0	70.6
	N	30;1*	58;29*	4;237*	92	267
# Days Used Per Year	m	140	231	266	204	262
	N	29;1	61;30	4;243	94	274
# Trips per Day	m	1.3	2.0	1.7	1.8	1.7
	N	30;1	55;26	4;227	89	254
#Shutoffs per Trip	m	2.1	4.0	3.6	3.0	3.7
	N	28;1	58;25	4;223	90	249
Fuel Economy (miles per gallon)	m	9.6	6.4	5.1	7.3	5.3
	N	30;1	54;29	4;236	88	266
# Years Owned	m	5.9	6.4	4.7	6.0	4.9
	N	29;1	60;29	4;237	93	267
Present Odometer Reading (1,000 miles)	m	51	111	409	83	389
	N	23;1	38;13	2;145	63	159
Odometer Reading at Purchase (1,000 miles)	m	3.8	4.6	7.3	5.3	6.5
	N	26;0	36;18	3;116	65	134
Avg. Weekday Mileage	m	23	83	233	70	216
	N	30;1	52;26	4;224	86	251
Avg. Weekend Day Mileage	m	11	53	126	48	115
	N	30;1	61;30	4;243	95	274
Unladen Weight (1,000 pounds)	m	8.7	10.0	23.7	10.2	22.2
	N	30;1	57;28	4;231	91	260
Laden Weight (1,000 pounds)	m	11.3	21.4	68.2	19.3	64.8
	N	22;1	42;20	4;237	68	258
Engine Size (cubic inches)	m	395	340	428	379	417
	N	21;0	32;17	4;181	57	198

*Number of gasoline-powered HDVs; number of diesel-powered HDVs in the sample.

Table 5-6. ANNUAL MILEAGE ACCUMULATION RATE BY VEHICLE TYPE

Vehicle Type	Annual Mileage 1977 TIUS	Annual Mileage 1985 CALTRANS
Recreational Vehicles	8,306	
Buses	15,579	
2-Axle Single-Unit Trucks	11,230	
3-Axle Single-Unit Trucks	20,252	
3-Axle Combination Trucks	25,000	
4-Axle Combination Trucks	35,900	
5+Axle Combination Trucks	62,048	
Dump Trucks		20,000
4-Axle Tractor-Semitrailers		70,000
Medium Distance 5-Axle Tractor-Semitrailers		70,000
Long Distance 5-Axle Tractor-Semitrailers		120,000

[a]U.S. Department of Commerce, Bureau of the Census, "1977 Census of Transportation, Truck Inventory and Use Survey: California", TC77-T-5, Issued October 1979, page 5-7.

[b]California Department of Transportation, "Highway Cost Allocation Study" Prepared for the Legislature pursuant to ACR109, 1984 Session, April 1985.

Average fuel economy of light, medium and heavy HDVs is, respectively, 9.6, 6.4 and 5.1 miles per gallon. Although Table 5-5 shows that average fuel economy of gasoline-powered HDVs is better than that of diesel-powered HDVs by nearly 40%, this happens to be so simply because gasoline-powered vehicles in the survey sample are mostly light HDVs while diesel-powered vehicles are mostly heavy HDVs. When HDVs in the same weight class are compared, the same survey results indicate that diesel-powered HDVs are about 20% more fuel efficient than gasoline-powered HDVs.

The average present odometer reading is 51,000 miles for light HDVs, 111,000 miles for medium HDVs and 409,000 miles for heavy HDVs. The average present odometer reading of 409,000 miles for heavy HDVs seems to be consistent with the Motor and Equipment Manufacturers Association (MEMA) study, estimating that the average vehicle use of heavy duty trucks in 1983 was 584,000 miles among fleet operators and 610,000 miles among owner operators (MEMA 1984). The same study also indicates that about 20% of heavy duty trucks have vehicle lives exceeding 1 million miles.

Average weekday mileage increases quite dramatically with vehicle weight, from 23 miles for light HDVs to 83 miles for medium HDVs and 233 miles for heavy HDVs. Average weekend day mileage follows the trend of average weekday mileage but is about 50% less than average weekday mileage.

Average unladen weights of light, medium and heavy HDVs are, respectively, 8,700, 10,000 and 23,700 pounds while average laden weights of the three weight classes are 11,300, 21,400 and 68,200 pounds, respectively. These increases in unladen vehicle weight from light to heavy HDVs accompany even sharper increases in the unladen-to-laden weight ratio: 1.30 for light HDVs, 2.14 for medium HDVs and 2.88 for heavy HDVs.

Responses to the questions on engine sizes and brake horsepower were considerably less complete than those to other questions. Indeed, the response rate for brake horsepower was only about a fourth of those for other (easier) questions. Furthermore, many of the responses gave rather unlikely values. Therefore, no statistics were computed for this parameter. The response rate for engine size was a little higher than a half of those for easier questions. Average engine sizes in cubic inches of displacement, are estimated to be 395 for light HDVs, 340 for medium

HDVs and 428 for heavy HDVs. However, the reliability of these estimates is questionable because of the low response rate.

Table 5-7 shows survey results on the questions regarding the seasonal variation of vehicle usage. In all three weight classes, about a quarter of the sampled HDVs were reported to be used evenly throughout the year while three quarters were said to be used unevenly (Table 5-7a). The percentage of vehicle use by season is the highest during the summer (31.8%) and the lowest during the winter (21.2%) (Table 5-7b).

Survey results on vehicle usage variation during the week are summarized in Table 5-8. Average percentage of vehicle use on a weekend day compared to that on a weekday is the highest in light HDVs (87%) and the lowest in medium HDVs (17%) among the three weight classes. Among the 31 light HDVs surveyed, 10 were reported to be used more on a weekday (32%), 8 used more on a weekend day (26%) and 13 used equally on both (46%). In contrast, about two thirds of the 247 heavy HDVs surveyed were reported to be used more on a weekday (69%) and none to be used more on a weekend day. A third of them were said to be used equally on both.

Table 5-9 shows survey results on the questions regarding the place of HDV usage. The results are contrary to common sense expectations of HDV usage patterns in that over two thirds of the heavy HDVs surveyed were said to be used in the home county only, or in the home county plus adjacent counties. Not one heavy HDV was reported to be used elsewhere, e.g., outside of California. Very similar results were obtained from the entire survey of 622 HDVs as well. This counterintuitive result may have been caused by the lack of clarity in the questionnaire question, which read:

> Q. Is the (Vehicle Name) used in the county registered in only (home county), the home county and adjacent counties, throughout California, or elsewhere.

Table 5-10 shows the distribution of fuels used for HDVs in each weight class. As anticipated, nearly all light HDVs use gasoline while nearly all heavy HDVs use diesel fuel. Only 1% of all HDVs surveyed use other types of fuel.

Table 5-7a. SEASONAL VARIATION OF VEHICLE USAGE BY WEIGHT CLASS

Seasonal Usage	Light HDV	Medium HDV	Heavy HDV	Total
Use Evenly	9 (21%)	23 (25%)	72 (29%)	104 (28%)
Use Unevenly	22 (71%)	70 (75%)	175 (71%)	267 (72%)
Total	31 (100%)	93 (100%)	247 (100%)	371 (100%)

Table 5-7b. PERCENTAGE OF USE BY SEASON FOR ALL HDVS

Season	Percentage of Use
Spring	23.7%
Summer*	31.8%
Fall	23.6%
Winter	21.1%

*The percentage over 25% means that HDVs are used more heavily in the summer than the annual average use.

Table 5-8. WEEKLY VARIATION OF VEHICLE USAGE BY WEIGHT CLASS

Weekly Usage	Light HDV	Medium HDV	Heavy HDV	Total
Use more on Weekday	10 (32%)	88 (95%)	171 (69%)	269 (73%)
Use more on Weekend Day	8 (26%)	1 (1%)	0 (0%)	9 (2%)
Use evenly	13 (42%)	4 (4%)	76 (31%)	93 (25%)
TOTAL	31 (100%)	93 (100%)	247 (100%)	372 (100%)
Weekend day use as percentage of average weekday mileage	87.2%	17.1%	32.3%	33.6%

Table 5-9. PLACE OF VEHICLE USE BY WEIGHT CLASS

Place of Use	Light HDV	Medium HDV	Heavy HDV	Total
Home County Only	12 (39%)	74 (80%)	177 (72%)	263 (71%)
Home County + Adjacent Counties	11 (35%)	0 (0%)	15 (6%)	26 (7%)
Throughout California	7 (23%)	19 (20%)	55 (22%)	81 (22%)
Elsewhere	1 (3%)	0 (0%)	0 (0%)	1 (0%)
Total	31 (100%)	93 (100%)	247 (100%)	371 (100%)

Table 5-10. MOTIVE POWER BY WEIGHT CLASS

Type of Fuel	Light HDV	Medium HDV	Heavy HDV	Total
Gasoline	30 (97%)	61 (66%)	4 (2%)	95 (26%)
Diesel	1 (3%)	30 (32%)	243 (98%)	274 (74%)
Other	0 (0%)	2 (2%)	0 (0%)	2 (1%)
Total	31 (100%)	93 (100%)	247 (100%)	371 (100%)

6.0 UNCERTAINTIES, PROJECTIONS AND FURTHER IMPROVEMENT

This section discusses uncertainties of the VMT and population estimates given in the preceding sections, and provides projections of those quantities to the years 1990 and 2000. Although the present study achieved and, in some cases, surpassed the original goals of the project, it also identified several important problems that need to be solved to permit further improvements in estimating truck VMT and the HDV population. The following three sections discuss, respectively, the uncertainties of truck VMT and population estimates, the projections of VMT and population to 1990 and 2000, and recommendations for further improvement of VMT and population estimates.

6.1 UNCERTAINTIES IN VMT AND POPULATION ESTIMATES

A difficulty in estimating truck VMT and the HDV population comes partly from the facts that the ARB definitions of HDVs and their three weight classes are different from most conventional classifications of vehicles. Specifically, the ARB weight classes bear no clear relation to either the standard weight classes (I through VIII) used by the FHwA or to "unladen weight" used by the DMV.

Although CALTRANS has two comprehensive VMT estimation programs (Truck Program and HPMS), these programs are designed to provide accurate VMT estimates for the state as a whole. CALTRANS VMT estimates for counties and districts are said to provide only "information" that can be used for local transportation planning and similar applications, rather than reliable VMT estimates. Even with the extensive networks of some 2,500 survey locations for the Truck Program and 2643 locations for the HPMS, CALTRANS personnel do not consider that their traffic data are sufficient to provide accurate VMT estimates for individual counties and CALTRANS districts (Ballard 1984).

This study has applied various apportioning parameters to the two CALTRANS data bases in order to obtain truck VMT estimates for various subregions and subcategories of HDV. Since the apportioning parameters themselves are subject to some errors, the resulting VMT estimates in this study are doomed to be less accurate than those given by the CALTRANS data bases. Likely sources and magnitudes of the errors in various VMT and population estimates presented in this report are discussed in two subsections which follow.

6.1.1 UNCERTAINTIES IN TRUCK VMT ESTIMATES

The FHwA guideline on traffic surveys for the HPMS (i.e., Appendix F of CALTRANS 1984) specifies the precision levels to be attained and the minimum sample sizes required for estimating an annual average daily traffic volume for each functional road class. For example, major functional classes such as interstate highways, freeways and principal arterials need to be sampled to attain the precision level of 90 - 5, meaning 90% of sample means fall within ± 5% of the true (population) mean. For a given a coefficient of variation and population size, Appendix G of the guideline provides a minimum sample size for each volume group of the functional class. CALTRANS' HPMS program has met or exceeded such minimum sample size requirements for all the functional classes it surveyed (CALTRANS 1984).

Therefore, 90-percent confidence limits of the statewide VMT estimated by HPMS would be within ± 5% of the estimated value. A similar precision level is expected for the VMT estimates for all urban roads, all rural road and statewide truck VMT. Since the Truck Program uses an even higher sampling rate for the state highway system than the HPMS program, 90% confidence limits of the statewide VMT estimated from the Truck Program would also be ± 5% or less. Thus, it can be said that the original VMT values estimated by the Truck Program and the HPMS are as accurate as ± 5% or better at the state level.

Table 6-1 presents annual statewide VMT estimates for all vehicles, which have been obtained separately from the Truck Program and the Traffic Accident Surveillance and Analysis System (TASAS). Ratios of the TASAS-based VMT values to the Truck Program VMT values range from 0.965 to 0.976 during the period, 1974 through 1982. These ratios are consistent with the fact that the Truck Program conducts its traffic survey during the three summer months (June through August) and thus should yield a higher VMT value than TASAS, which conducts its traffic survey in all four seasons.

Table 6-1. COMPARISON OF ANNUAL ALL VEHICLE VMT ESTIMATED FROM TRUCK PROGRAM AND TASAS (CALTRANS) DATA BASES

Year	TASAS* (A) (billions)	Truck Program (B) (billions)	(A/B)
1974	69.026	71.286	.96830
1975	72.450	74.647	.97057
1976	77.154	79.022	.97637
1977	80.737	83.553	.96629
1978	85.806	88.627	.96817
1979	86.640	89.323	.96996
1980	87.610	90.054	.97286
1981	91.343	94.609	.96548
1982	92.581	95.522	.96921

*Traffic Accident Surveillance and Analysis System

The size and consistency of the ratios lend further substance to the validity of the CALTRANS VMT data bases.

Compared to the all-vehicle VMT data described above, CALTRANS truck VMT data are expected to be less accurate because of following the factors:

- Two axles and six tires constitutes a useful criterion for visually distinguishing trucks from other vehicles but not an accurate criterion for differentiating HDVs from other vehicles.

- Traffic count data of the Truck Program are gathered by trained CALTRANS personnel but traffic count data of the HPMS come from counties and metropolitan planning organizations as well as from CALTRANS' district offices.

- The HPMS does not provide truck VMT estimates but does provide all-vehicle VMT and statewide average truck content in traffic for each functional class of roads and each traffic volume range.

All three factors cause errors in the truck VMT estimates. These are primarily systematic rather than random errors. However, one source of random error, estimated to be about 1% to 2%, is due to misclassification of vehicles by traffic surveyors (see Appendix A). The criterion of two-axle, six-tired vehicles as HDVs tends to overcount HDVs in traffic by including some non-HDVs. Such erroneous inclusions may occur in lighter 2-axle vehicles categorized as van (2V), pickup with flat bed (2PF), pickup with camper shell (2PC), pickup with box cargo space (2PB), wrecker (2W), motor home (2MH), minibus (2MB), and cutaway van (2CV). These vehicles appear to belong to FHwA Weight Class II ($6{,}000 < GVW \leq 10{,}000$ lbs) and, thus, are the most difficult to classify as HDVs or non-HDVs.

Although no confirmatory efforts were made, PES staff members encountered many seemingly-non-HDVs during the PES special Truck Traffic Survey. Since all these vehicles have been identified in Appendix C as one of the vehicle categories mentioned above, the extent of VMT overestimation due to erroneous inclusion of such vehicles can be determined later.

Effects of the second and third factors on truck VMT estimates would be the most difficult to quantify, even if they could be quantified. However, it is apparent that these two factors work to diminish the accuracy of <u>local</u> VMT estimates (such as for counties and air basins) because of the non-uniformity of quality of the data gathered.

Starting with the VMT data provided by the two CALTRANS programs (i.e., Truck Programs and HPMS), PES has developed a set of apportioning parameters and applied them to the CALTRANS VMT data to obtain spatially resolved and finally categorized truck VMT estimates. These apportioning parameters include truck mix for non-state roads, axle-class-to-HDV-weight-class conversion, motive power split for vehicles in each weight class, and proportion of out-of-state HDVs to truck VMT on California roads. Since all these parameters have been estimated from limited data and information, their estimated values contain a certain error, causing either under- or over-estimates of VMT by a particular HDV category across the state.

All the apportioning parameters are point estimates, i.e., estimates for the entire state instead of spatially resolved estimates. Applications of such point-estimated parameters to the spatially resolved CALTRANS VMT data may have introduced additional errors in local VMT estimates. In this regard, VMT estimates given for a small geographical area and for a small subcategory of HDVs should be used with caution. The VMT numerals after the first three digits are uncertain for large geographical areas like the state and the SCAB, and are extremely uncertain for small geographical areas such as counties and for small HDV categories, such as diesel-powered light HDVs.

6.1.2 UNCERTAINTIES IN HDV POPULATION ESTIMATES

As can be seen from Tables 5-1 and 5-2, the vehicle populations in the borderline classes (e.g., Recreational Vehicle Class in Table 5-1 and Class II in Table 5-2) are nearly as large as or larger than the estimated VMT population. For example, the numbers of recreational vehicles (423,000) and Class II vehicles (975,000) are about the same as or greater than the estimated numbers of HDVs (571,000 and 476,000 in the two tables). This makes it very difficult to determine the VMT population accurately. As explained in Section 5, the difficulty arises mainly from the ARB's definition of HDVs as vehicles with GVW over 8,500 pounds, which fall in the middle of the weight range for Class II ($6,000 < GVW \leq 10,000$).

ARB has developed a set of percentage HDV contents for various vehicle body styles and applied these percentages to DMV vehicle-registration data to obtain an estimate of the HDV population. This method suffers from the defect that vehicles with a given body style have a wide range of GVW and that DMV data are based on "unladen weight."

Sydec (1984) applied the results of the 1977 TIUS to DMV registration data to estimate the truck population, where trucks were defined as vehicles with two or more axles and having at least six tires. This method suffers from the defect that "trucks" are not exactly same as HDVs and that the results of the TIUS nationwide survey are not necessarily representative of the California vehicle population.

The CEC used the Polk-provided GVW data to develop estimates of the vehicle population of each of the eight standard weight classes (as listed in Table 5-2). Although not attempted in this study, it seems possible to apply ARB's percentage HDV contents to estimate the number of HDVs among Class II vehicles. Polk will be able to provide a detailed breakdown of the Class II vehicle population by body-style. By applying the percentage HDV content in each body style to the Class II population breakdown, one can calculate the number of HDVs in Class II. This method appears to be more promising than the present ARB method because Class II vehicles with a given body style should have a considerably narrower range of GVW than all vehicles with the same body style have.

Drawbacks of this suggested method are: (1) Polk data are somewhat outdated; and (2) Polk data are rather expensive to obtain, particularly when a specific format of the data is requested.

6.2 PROJECTIONS OF TRUCK POPULATION AND VMT

There are two general approaches in making projections; one is based on historical trends, and the other is based on the use of economic models (like a supply-demand model). CALTRANS has accumulated truck VMT data for ten years, 1974 through 1983. DMV has historical data on vehicle registration records. These data can be used for making projections of truck VMT and the vehicle population. The CEC has developed a California

Freight Energy Demand Model and has made projections of vehicle stock, VMT, ton-miles and fuel use (JFA 1983).

Table 6-2 presents projections of vehicle stock in California to the years of 1990 and 2000. The population is predicted to grow from the base-year populations of 476,000 HDVs to 542,000 in 1990 and 564,000 in 2000. These increases will reflect increases in both light and heavy HDVs, but the number of medium HDVs is predicted to decrease in the future years. This prediction is based on the CEC finding that, due to the economy of vehicle hauling capacity, some medium-size trucks will be replaced by combination trucks while down-sizing of vehicles will make some medium-size trucks light enough to be classified as light HDVs (JFA 1983).

Table 6-3 provides projected numbers of vehicles by vehicle type for the years of 1990 and 2000. The projections are based on the estimated vehicle population in 1983 and a historical annual growth rate in vehicle registration records. The truck population is predicted to grow from 571,000 in 1983 to 601,000 in 1990 and 644,000 in 2000. Unlike the CEC forecast, the number of combination trucks is predicted to remain the same as the 1983 population. Instead, a significant growth in the population of single unit trucks is predicted. The zero growth in combination trucks may indicate that fleet owners of apportioned license trucks are switching their vehicle registration from California to other states.

Table 6-4 presents the estimated and projected truck VMT for the years 1977 (base year), 1980, 1990 and 2000. Despite the CEC projections, no decline in VMT is predicted for medium HDVs. In fact, the VMT growth for medium HDVs is predicted to be nearly as large as that for heavy HDVs and larger than that for light HDVs. This happens to be so because annual mileage accumulation rates for trucks, in general, and for medium HDVs in particular, are predicted to grow considerably in the future years (JFA 1983).

Table 6-5 shows CALTRANS estimates of statewide truck VMT on the state highway system in each of the past 10 years, 1974 through 1983. The VMT has grown in all axle classes during the period and is projected to grow further by the years 1990 and 2000. Two-axle and 5+axle trucks are projected to contribute to total truck VMT by 85% in 1990 and 86% in 2000.

Table 6-2. PROJECTIONS OF VEHICLE STOCK IN CALIFORNIA BY WEIGHT CLASS
(after JFA 1983, all values in 1,000's)

Weight Class (GVW in lbs)	Year 1977	1980	1990	2000
1. II (6 - 10)	975	(1,178)[a]	(1,258)[a]	(1,248)[a]
2. III,IV,V (10 - 19.5)	65	57	39	33
3. VI (19.5 - 26)	91	99	89	86
4. VII (26 - 33)	9	11	17	26
5. VIII (over 33)	23	24	29	34
6. Combination Trucks	93	98	116	135
Classes 1 through 6	1,256	1,467	1,548	1,562
Classes 2 through 6	281	289	290	314
Light HDV[b] (8.5 - 14)	217	255	265	261
Medium HDV (14-33)	143	148	132	134
Heavy HDV (over 33)	116	122	145	169
HDV Total	476	525	542	564

[a]The numerals in parenthesis were calculated by applying the growth factors presented in the Phase I Report (JFA 1982) to the 1977 value.

[b]Estimated as (1/5 of Class II + 1/3 of Classes III, IV and V).

Table 6-3. ESTIMATED AND PROJECTED NUMBERS OF VEHICLES BY VEHICLE TYPE IN CALIFORNIA
(after Sydec 1984; all values in 1,000's)

Vehicle Type	1983	Annual Growth Rate	1990	2000
1. Recreational Vehicles	423	14.0	521	661
2. Buses	46	0.4	49	53
3. Single Unit Trucks	429	3.9	456	495
4. Combination Trucks	96	0.0	96	96
Classes 1 through 4	994		1,122	1,305
Classes 2 through 4	571		601	644

Table 6-4. PROJECTIONS OF STATEWIDE ANNUAL AVERAGE DAILY TRUCK MILES OF TRAVEL BY WEIGHT CLASS (after JFA 1983, all values in millions)

Weight Class (GVW in 1,000 lbs)	Year 1977	1980	1990	2000
1. II (6 - 10)	(31.1)[a]	(36.3)[a]	(37.9)[a]	(41.9)[a]
2. III,IV,V (10 - 19.5)	1.3	1.3	1.3	1.3
3. VI (19.5 - 26)	3.0	3.4	3.8	4.0
4. VII (26 - 33)	0.3	0.5	0.9	1.5
5. VIII (over 33)	1.3	1.5	1.9	2.2
6. Combination with Single Trailer	7.2	8.3	10.3	11.6
7. Combination with Double Trailer	3.7	4.2	5.0	5.8
Classes 1 through 7	47.9	55.5	61.1	68.3
Classes 2 through 7	16.8	19.2	23.2	26.4
Light HDV[b] (8.5 - 14)	6.7	7.7	8.0	8.8
Medium HDV (14-33)	4.2	4.8	5.6	6.4
Heavy HDV (over 33)	12.2	14.0	17.2	19.6
HDV Total	23.1	26.5	30.8	34.8

[a]The numerals in parenthesis were calculated from values presented in the Phase I Report (JFA 1982).

[b]Estimated as (1/5 of Class II + 1/3 of Classes III, IV and V).

Table 6-5. TRENDS AND PROJECTIONS OF STATEWIDE ANNUAL AVERAGE DAILY TRUCK VMT ON THE STATE HIGHWAY SYSTEM (after CALTRANS 1983, all values in millions)

Year	Axle Class 2-Axle	3-Axle	4-Axle	5+Axle	All Trucks
1974	5.8	1.7	0.8	6.9	15.2
1975	6.2	1.8	0.8	7.2	16.0
1976	6.7	1.9	0.9	7.8	17.2
1977	7.0	2.0	1.0	8.4	18.4
1978	7.7	2.2	1.0	9.3	20.3
1979	7.9	2.2	1.1	9.9	21.1
1980	8.2	2.3	1.1	10.6	22.3
1981	8.7	2.5	1.1	11.4	23.7
1982	8.9	2.5	1.1	11.4	24.0
1983	9.3	2.6	1.2	12.0	25.1
Avg. Annual Growth Rate	0.35	0.09	0.04	0.51	0.99
1990	11.8	3.2	1.5	15.6	32.1
2000	15.3	4.1	1.9	20.7	42.0

The CEC study (JFA 1983) was designed to estimate and project statewide truck activities. However, the CEC estimates exceed the truck VMT on the state highway system by only 26% and 19%, respectively, in 1977 and 1980. Their projected VMT values for 1990 and 2000 are less than those projected from the historical CALTRANS truck VMT estimates.

This study has estimated that in addition to 25 million daily VMT on the state highway system, trucks accumulated in 1983 another 11 million daily VMT on city and county roads, for a total statewide truck travel of 36 million vehicle miles per day. Assuming that the same proportions of truck VMT on the state highway system and on the off-state highway system persist in future years, the projected statewide truck VMT in 1990 and 2000 will be 46 million (= 32 million x 36/25) and 60 million, respectively.

6.3 RECOMMENDATIONS FOR FURTHER IMPROVEMENTS

Under the present study, PES has developed an alternative method of estimating truck activities in California, based on the CALTRANS annual and biennial studies: HPMS and Truck Program. To make the alternative method more accurate in obtaining estimates of truck VMT and HDV emissions, PES recommends the ARB to undertake the following:

(1) ARB should study the GVW distributions for 2-axle, 6-tire vehicles in pickup, van and other light vehicle types to determine how well CALTRANS - defined "trucks" approximate HDVs.

The present study is based on an assumption that CALTRANS-defined "trucks" reasonably approximate HDVs. Although the assmption seems to be good, no rigorous examination has not been made to determine how accurate the approximation really is. For this purpose, ARB should analyze the vehicle profile data obtained by the PES Special Truck Traffic Survey and by the CALTRANS biennial Classified Vehicle Survey at weigh stations, together with the vehicle weight distribution data which can be obtained from DMV and some other data source.

The PES Survey data (given in Appendix C) provide detailed counts by body type for city and county roads while the CALTRANS Survey data provide similar information for state highways. If one assesses the typical GVW range for two-axle, six-tire vehicles in each body type, he will be able to determine, for each road type, what fraction of "trucks" is indeed HDVs. By applying such fractions to the CALTRANS truck VMT data, one can calculate VMT by HDVs more accurately than by the method presented in this report.

(2) ARB should analyze data from the recently completed CALTRANS survey of 6,000 trucks, whose operators were interviewed at weigh stations last August, in order to improve the estimates of out-of-state truck activities on California roads.

In this study, the proportions of out-of-state trucks in heavy, medium and light HDVs were estimated by using data from the 1976 ICC Survey and the 1971 ITTE Survey. Although these surveys were well designed and quite complete, they are pretty old by now. The special weigh station survey conducted by CALTRANS in August, 1984 appears to provide valuable and quite recent information on the activities of out-of-state trucks on the state highway system. CALTRANS polled drivers of 6,000 trucks which entered survey weigh stations and measured the weight and length of each vehicle. Analysis of this survey data will yield an upgraded estimate of out-of-state activity on the state highway system. To obtain an improved estimate of the out-of-state truck activities on city and county roads, a special survey like the ITTE survey of 1971 may be necessary. In the ITTE survey, a team of Highway Patrol officers experienced in commercial vehicle work conducted interviews at several temporary stations, in metropolitan areas as well as at regular weigh stations.

(3) ARB should use a set of vehicle-type-specific, road-type-specific diurnal profiles of vehicle traffic to obtain accurate hourly VMT estimates for HDVs.

To obtain hourly gridded emission data for air quality assessment studies, ARB applies a typical dirunal pattern of traffic to the mobile source emission inventory under study. However, the diurnal profile of truck traffic differ distinctly from that for passenger cars and from that for all vehicles. Similar differences in diurnal traffic pattern are noticed between 2-axle and 5+axle trucks and between different road types. Although somewhat old, there are a few comprehensive studies which provide vehicle-type- and road-type-specific diurnal profiles. For example, the 1967 CALTRANS Classified Vehicle Study contains a wealth of data from which temporal variations (both diurnal and seasonal) of traffic by vehicle type and road type can be estimated. Table 6-6 shows the diurnal profiles of traffic by vehicle type for the entire state highway system. Similar profiles are given in the CALTRANS study for specific road types and several subregions as well.

By using these vehicle-type-specific diurnal profiles, ARB will be able to calculate a composite profile which will be most representative of truck traffic in a particular area under study.

Table 6-6. HOURLY PERCENTAGE OF ANNUAL AVERAGE DAILY TRAFFIC BY VEHICLE TYPE (from CALTRANS 1970)

	A.M.									Hour of Day							P.M.						
Types of Vehicle	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Auto	1	1	1	–	–	1	4	6	6	6	7	7	6	6	7	7	8	7	5	4	3	3	2	2
Auto with trailer	1	1	1	1	1	1	3	4	5	7	8	8	8	8	8	8	6	5	4	3	3	2	2	2
Bus	3	1	1	3	1	1	5	6	6	6	6	5	5	6	6	8	6	5	5	3	3	3	3	3
Pickup	1	–	–	–	1	2	8	10	6	6	6	5	5	5	6	7	10	8	4	3	2	2	1	1
Non-truck total	1	1	1	–	1	1	5	6	6	6	7	7	6	6	6	7	8	6	5	4	3	3	2	2
Truck total	3	3	3	3	3	4	4	4	5	5	5	5	5	6	6	6	5	5	4	4	3	3	3	3
All Vehicle Total	1	1	1	1	1	1	4	6	6	6	6	7	6	6	6	7	8	7	5	4	3	3	2	2
2-axle truck	1	1	1	1	1	2	4	6	7	8	7	7	6	7	8	8	8	5	4	3	2	1	1	1
3-axle truck	2	1	2	2	2	3	5	5	8	6	6	6	6	6	6	6	6	6	4	3	3	2	2	2
4-axle truck	2	2	2	2	2	2	2	5	5	5	5	7	5	7	7	7	7	5	5	4	3	3	3	2
5+axle truck	4	4	4	4	5	5	4	3	3	4	4	4	5	5	5	5	4	4	4	4	4	4	4	4
Truck Total	3	3	3	3	3	4	4	4	5	5	5	5	5	6	6	6	5	5	4	4	3	3	3	3

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